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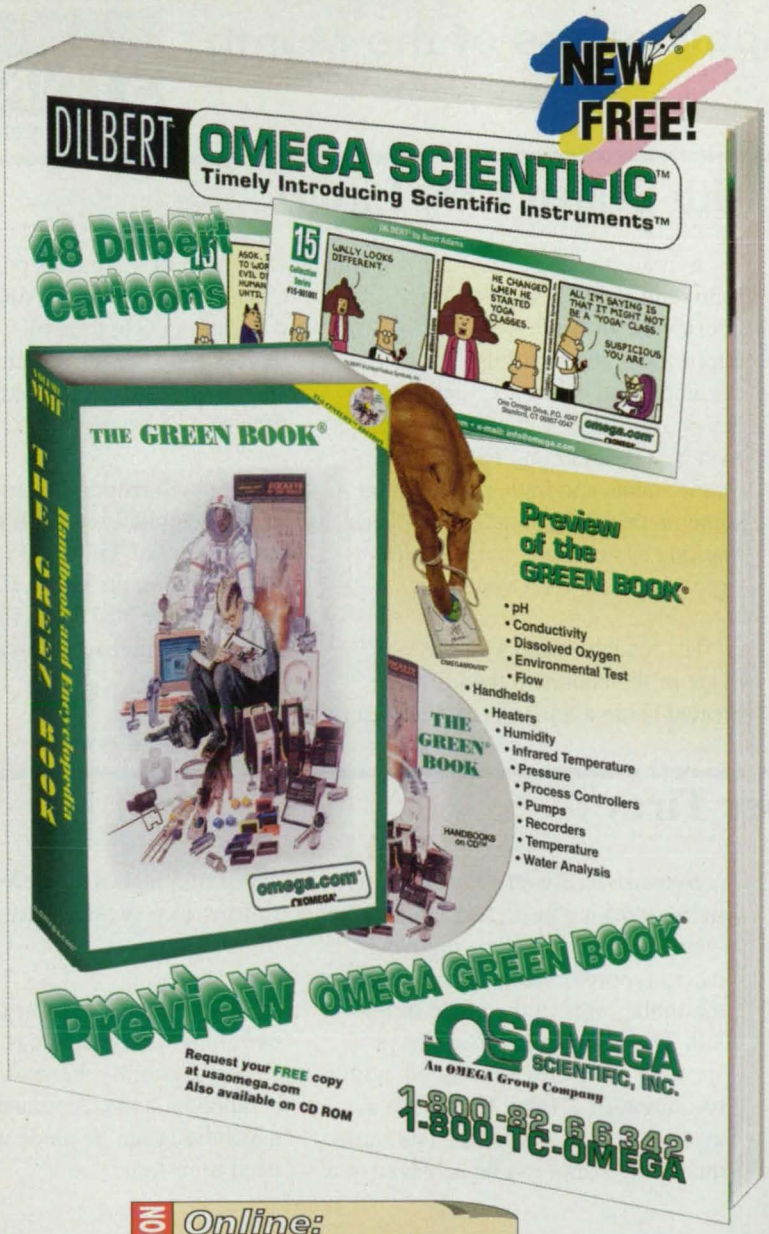

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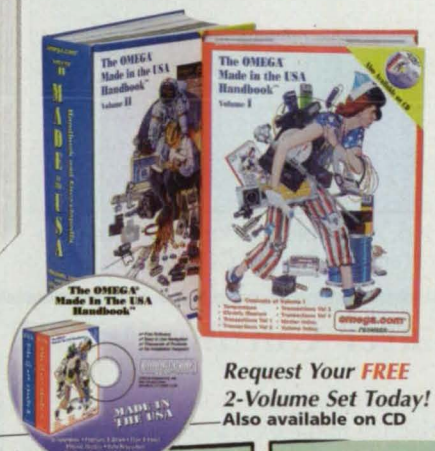

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CO_2 Laser Applications of the Month

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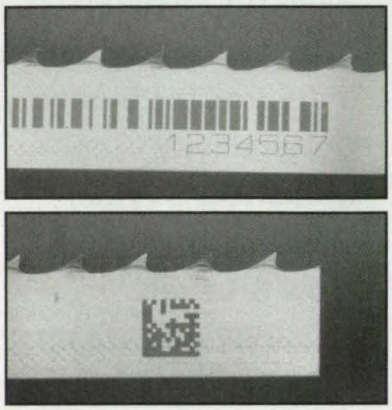
Marking Saw Blades with Sealed CO_2 Lasers



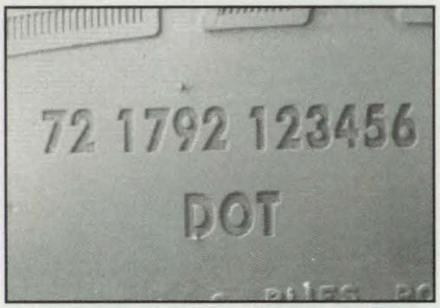
These codes were marked on a stainless steel saw blade with a 125-watt Synrad laser.

Synrad lasers are ideal for marking mild and stainless steels. Often considered an Nd: YAG laser application, steel marking can be easily accomplished with a CO_2 laser. CO_2 lasers offer users a number of benefits over YAGs, including fewer safety requirements and higher contrast on some metals. Additionally, CO_2 laser marking systems are generally less expensive than YAG systems.

The readable marks on the saw blade in the photos to the left were created using a Synrad 125-watt laser at a speed of 4.5 inches per second, and a resolution of 425 dpi. The matrix code has a cycle time of 5.7 seconds, the bar code has a cycle time of 18.9 seconds, and the filled text has a cycle time of 47.8 seconds.

Engraved marks on thin metal would potentially weaken the strength of the material, but these permanent, contrasting marks were created on the surface of the blade, leaving the strength of the material unaffected.

Laser Marking Rubber Tires



Crisp, readable marks can be created on tires with Synrad CO_2 lasers.

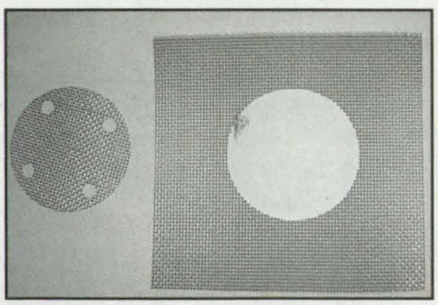
Synrad's 125-watt CO_2 laser, FH-Series marking head, and 200mm lens were used to create the engraved marks (approximately 10mm high) on the rubber tires in the photo to the left. The marks were created at a speed of 25 inches per second, with a resolution of 250dpi, to achieve a cycle time of 4.7 seconds. The same quality of marks can be achieved at a speed of 5 inches per second (cycle time of 16.6 seconds) using 25 watts of power.

The advantage of laser marking over molded characters is clear: part-to-part flexibility, barcoding, serializing, and customization capabilities can be made without the need to re-tool.

Laser Cutting Bronze Mesh

Although bronze is highly reflective to the CO_2 wavelength, we were able to cut this 0.028"-thick mesh using a Synrad 240-watt CO_2 laser and 40psi oxygen assist gas. Cutting speed was increased from 7 to 32 inches per minute by simply placing a 0.01"-thick sheet of paper on top of the mesh.

The paper provides an extra layer of absorption, transmitting more of the laser heat into cutting power. The spacing between the wires (rather than having a solid sheet) also aids in the absorption of the laser beam.



Bronze mesh cut with a 240-watt Synrad CO_2 laser.

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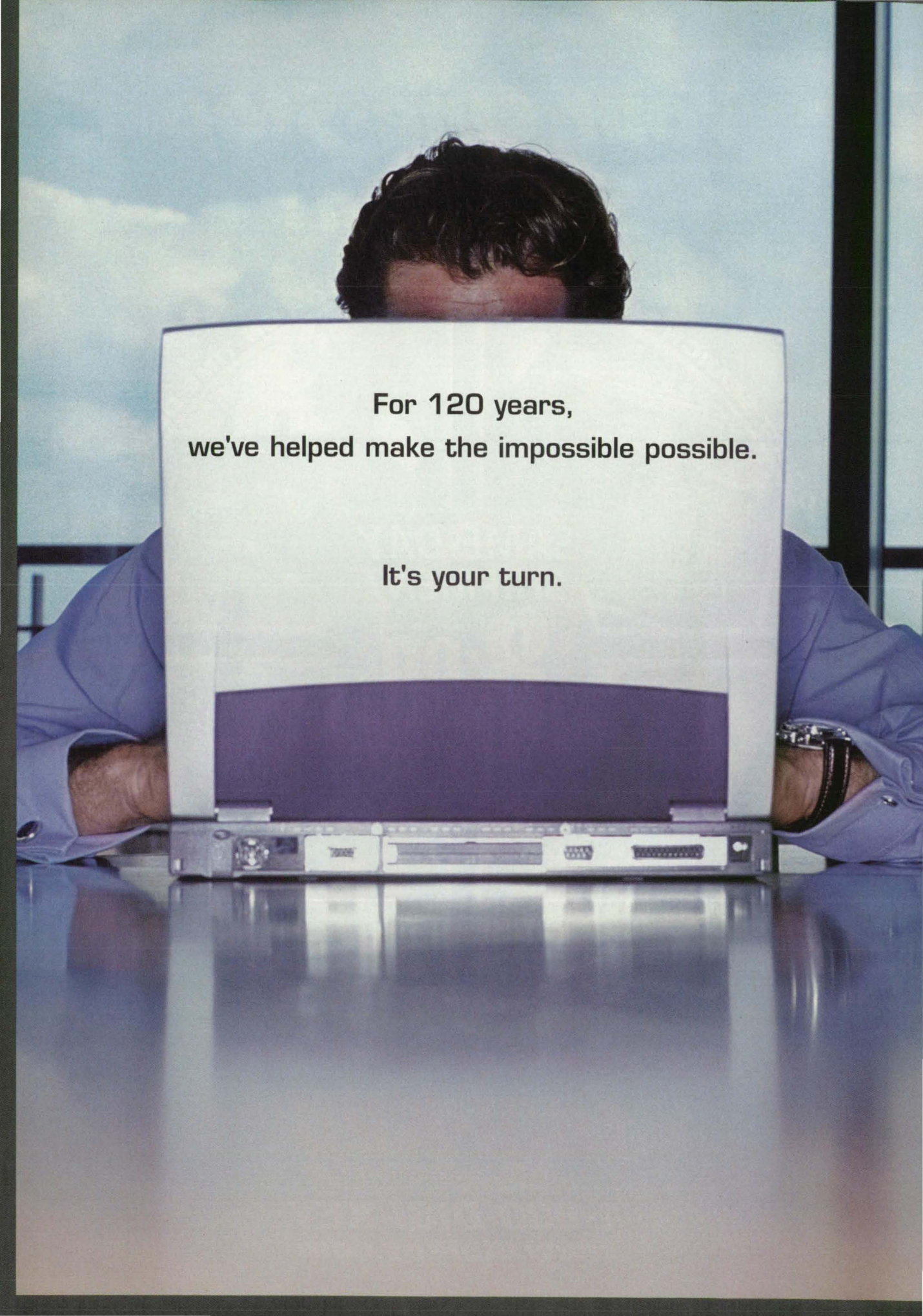
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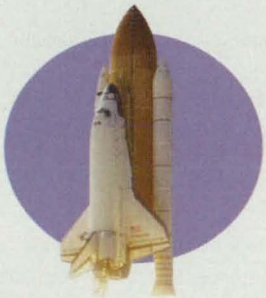

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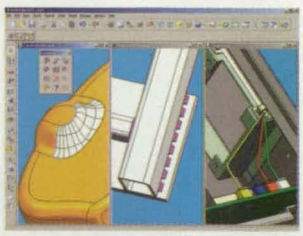

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SOLUTIONS

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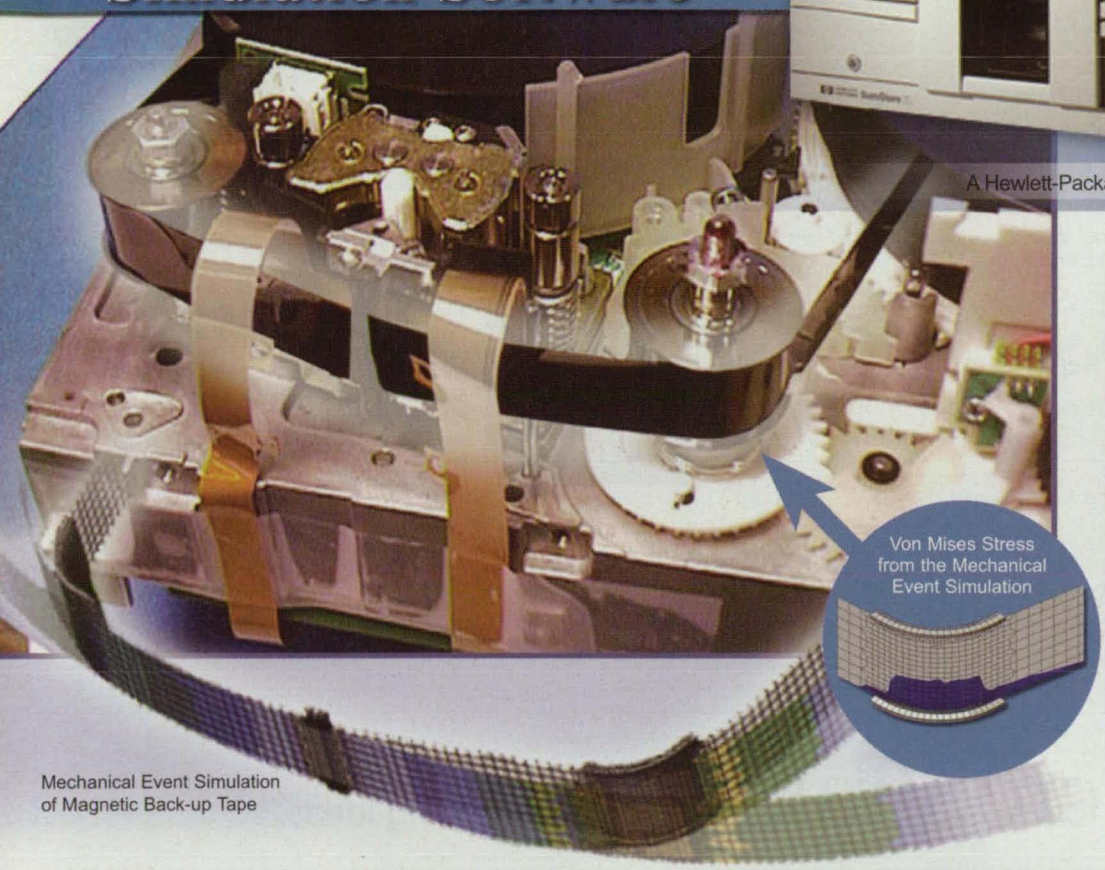
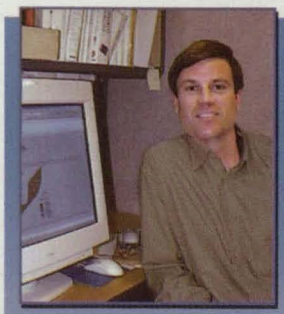
SPECIAL SUPPLEMENT

Hewlett-Packard Optimizes New Tape Drive with Simulation Software

A Hewlett-Packard LTO Ultrium Back-up Drive



Mechanical Event Simulation
of Magnetic Back-up Tape



"The software's early prediction of the stress levels enabled me to make adjustments and optimize the design."

Paul Poorman
Mechanical Engineer
Hewlett-Packard Company

Hewlett-Packard Chooses ALGOR FEA to Extend the Life of Back-up Tape

Linear Tape-Open (LTO) technology, developed jointly by Hewlett-Packard Company (HP), IBM and Seagate, replaces proprietary formats for corporate back-up solutions with an open tape format that makes it easier for customers to choose products. Hewlett-Packard used ALGOR's Mechanical Event Simulation (MES) software to analyze the behavior of the magnetic recording tape as it is wound through a Hewlett-Packard LTO Ultrium back-up drive.

The Challenge

Hewlett-Packard's challenge was to optimize the LTO drive to increase tape durability while maintaining tape path stability. To study the tape's behavior, the software had to simulate motion, contact between parts in an assembly, large displacement, elastic material behavior and stresses.

For this complete story and others, visit hptapedrive.ALGOR.com

The Solution

A Hewlett-Packard engineer, Paul Poorman, modeled the magnetic tape with isotropic shell elements and the drive assembly using kinematic elements. In the MES, the tape wraps around two rollers and across a tape head and is then pulled into a take-up reel. The MES results showed the motion of the tape and resulting stresses. These results helped Hewlett-Packard find a proprietary solution that keeps the tape on track while reducing stresses on the edge of the tape, thus extending the life of the back-up tape. Paul Poorman reports, "The first generation of Hewlett-Packard Ultrium drives is currently in the market and performing well."

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PRODUCT OF THE MONTH

The xPC TargetBox™ from The MathWorks, Natick, MA, is an industrial PC that performs real-time analysis, simulation, and testing of control and DSP systems.

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ON THE COVER

Rugged portables are a fast-growing segment of the computer hardware market. Used by field engineers for test and data acquisition applications, they combine desktop power and a tough enclosure. One of these systems is the FlexPAC®, a six-slot version of the FlexPAC™ rugged portable from Dolch Computer Systems, Fremont, CA. The FlexPAC® provides Pentium® 4 processing power with six full-size PCI and/or ISA expansion slots. Read more about the next generation of computer hardware in the feature beginning on page 27.

(Image courtesy of Dolch Computer Systems)

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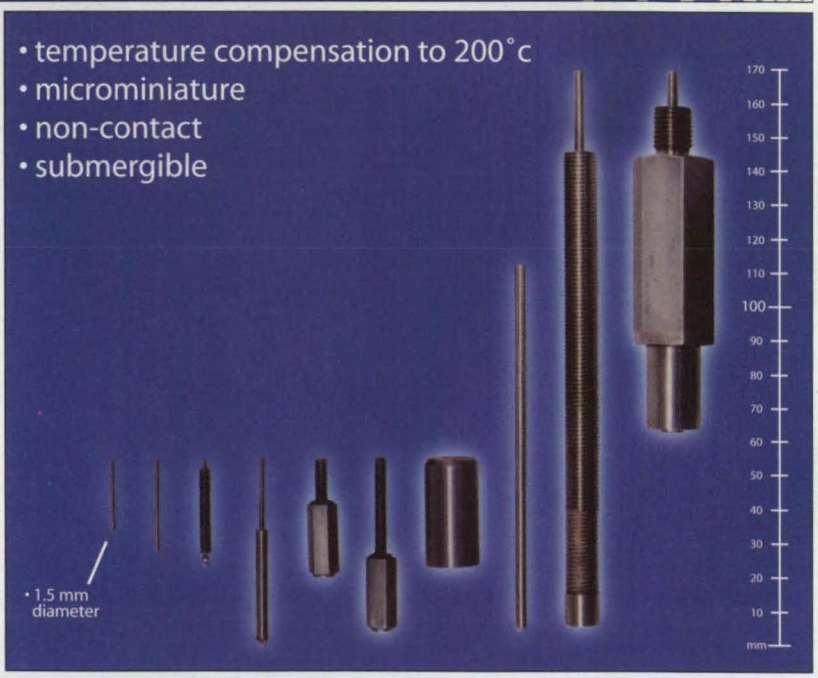

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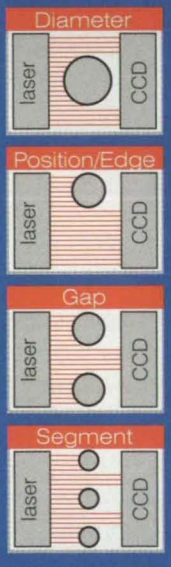

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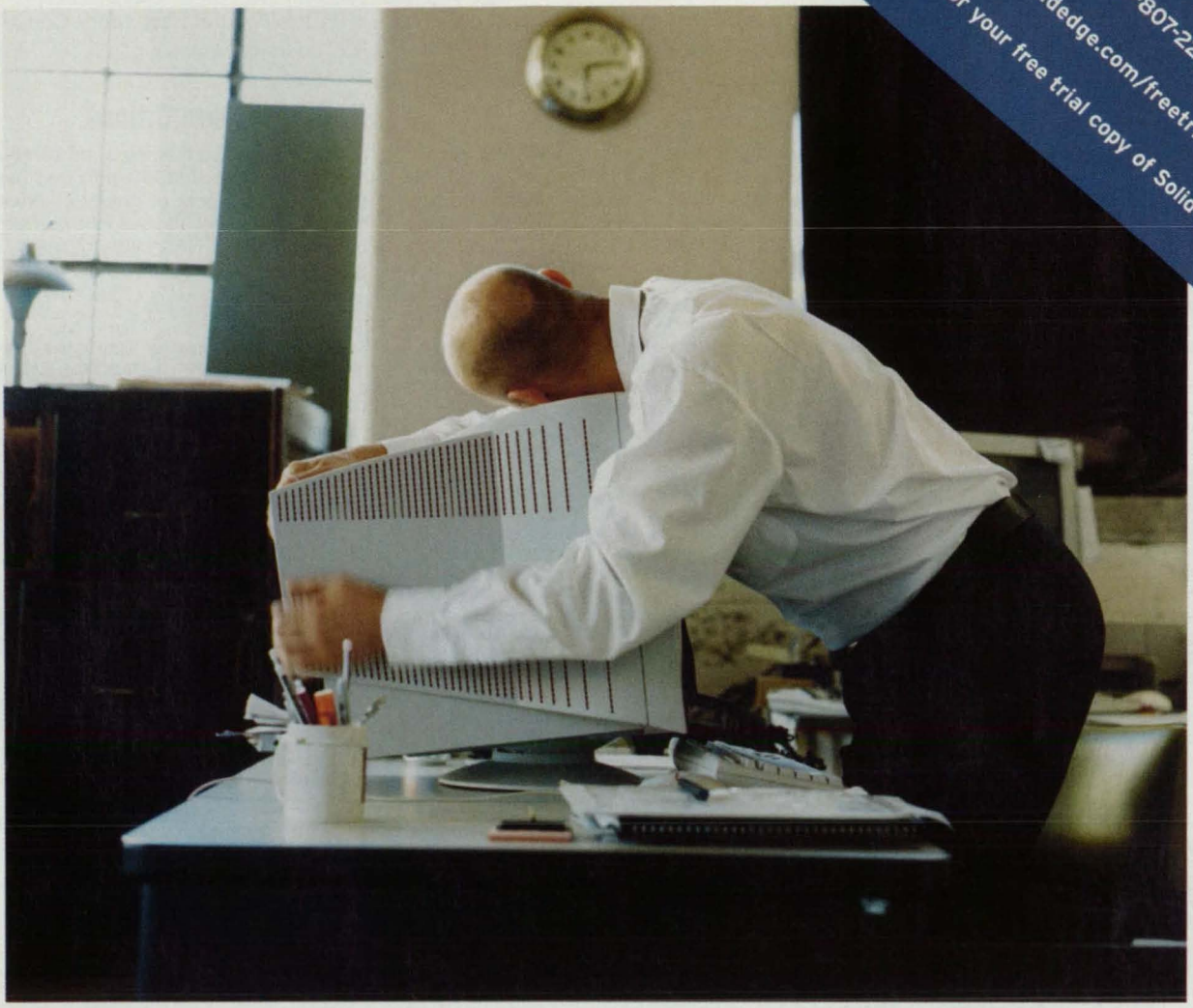

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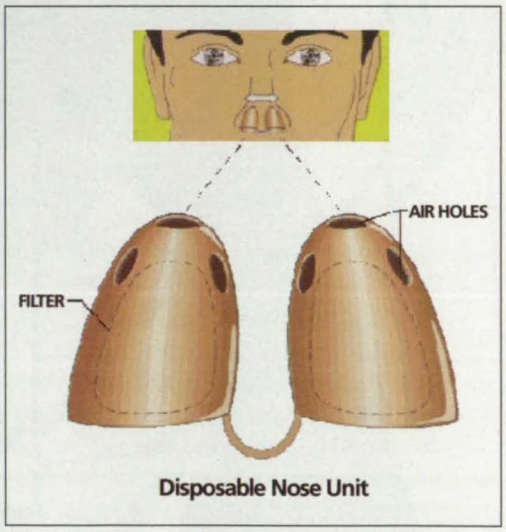
PRODUCT OF THE MONTH

The xPC TargetBox™ from The MathWorks, Natick, MA, is an industrial PC for use in performing real-time analysis, simulation, and testing of control systems and digital signal processing (DSP) systems. The box works with xPC Target software, a host-target environment that lets users connect models created in other MathWorks design tools — such as Simulink®, MATLAB®, and Real-Time Workshop® — to physical systems, and execute them in real time. Users can select from eight I/O options to suit their requirements, including analog input, analog output, digital input and output, counters and timers, CAN bus interface, pulse width modulator output, and encoder input. The box holds up to three boards, and all connections, cables, and screw terminal boards are provided. Also included is an external floppy drive, AC/DC power supply for mobile applications, 128 MB RAM, and a choice of three processors: a 266-MHz Pentium® II; a 400-MHz Pentium III; and a 700-MHz Pentium III. A monitor, keyboard, and mouse can be attached to the box to use it as a standalone PC.

For Free Info Visit www.nasatech.com/mathworks9

NASA-Funded Program Helps Develop New Products

The NASA-funded Space Alliance Technology Outreach Program (SATOP) provides small businesses with free technical assistance through the use of the U.S. Space Program, as well as aerospace companies, NASA field centers, and universities. Recently, SATOP helped a small Florida business launch a new commercial product.



Disposable Nose Unit

Toby's Nose Filters of Merritt Island, FL, already had developed an apparatus that can be inserted into a person's nose to filter debris, dust, and pollen while allowing air to flow. Company owner Toby McCormick wanted to develop a dual-filter that would also filter out offensive odors such as cigarette smoke.

McCormick contacted the SATOP center in Florida, which paired him with the State University of New York's College of Environmental Science and Forestry (SUNY-ESF). An ESF professor who specialized in filtration recommended to McCormick the use of activated carbon in the form of carbon filaments for the dual-filter.

According to McCormick, the new dual-filter is a success. "As a result of being able to produce this filter, we have uncovered a source of prospective buyers that we never knew existed," he said.

For more information on SATOP, or to request assistance, visit ***www.SpaceTechSolutions.com.***

Design and **Win!**

We're pleased to announce the first-ever Emhart Design Contest: "Create the Future," sponsored by Emhart Teknologies (New Haven, CT) and ABP International, publisher of *NASA Tech Briefs*. This is your chance to submit an original design idea in one of these three categories:

- **Safety** — mechanical or electromechanical designs to improve personal safety during travel, work, recreation, or at home;
- **Transportation** — mechanical or electromechanical designs that improve the functionality, performance, or cost basis of transportation products; and
- **Everyday Products** — significant functional or ergonomic new products, or upgrades to existing products, that improve quality of life.

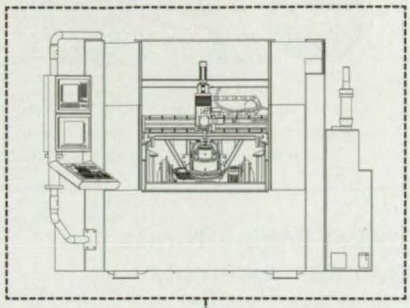
To enter, complete the official entry form at **www.emhartcontest.com**. Entries will be judged on innovation, manufacturability, marketability, and cost-effectiveness by an independent panel of judges.

The Grand Prize winner will receive a hybrid automobile or $20,000 in cash. One First Prize winner will receive a Segway Transporter or a trip for four to Florida to tour NASA's Kennedy Space Center and attend a Space Shuttle launch. Dozens of other prizes will be awarded, and all qualified entrants will receive a POP® PowerLink 30 repair kit/hand rivet tool from Emhart, valued at $50.

So, get those creative juices flowing — entries must be received by November 15, 2002. Winning entries will be featured in *NASA Tech Briefs*. See the ad on pages 4-5 of this issue for more information, and be sure to visit the official contest Web site at **www.emhartcontest.com** for entry rules.

Next Month in NTB

Find out in the October issue how the U.S. Speedskating team used NASA optics polishing technology to help them win 11 medals at the 2002 Olympics. Also, read about how manufacturers are using the latest robotic, assembly, and automation hardware and software to get their products to market faster.



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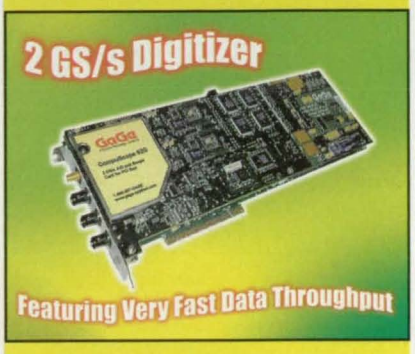

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NASA Patents

Over the past three decades, NASA has granted more than 1000 patent licenses in virtually every area of technology. The agency has a portfolio of 3000 patents and pending applications available now for license by businesses and individuals, including these recently patented inventions:

Rocket Engine Thrust Chamber Assembly

(U.S. Patent No. 6,330,792)

Charles S. Cornelius, Richard H. Counts, Jeffrey D. Lackey, Timothy W. Lawrence, W. Neill Myers, Warren Peters, Michael D. Shadoan, and David L. Sparks, Marshall Space Flight Center

A thrust chamber assembly for liquid-fueled rocket engines is made by wrapping a two-piece mandrel with a silica tape saturated with a phenolic resin. The tape extends along the mandrel and covers the combustion chamber portion of the mandrel to the throat. The phenolic in the tape is cured and the end of the wrap is machined. The remainder of the mandrel is wrapped with a third silica tape. The resin in the third tape is cured, and the assembly is machined. The entire assembly is then wrapped with a tow of graphite fibers wetted with an epoxy resin and, after the epoxy resin is cured, the graphite is machined to final dimensions.

Silica tape is commercially available, and is woven from fiberglass fibers and treated with nitric acid, which leaches out the sodium and lithium to leave a silica fabric.

Non-Destructive Evaluation Method and Apparatus for Measuring Acoustic Material Nonlinearity

(U.S. Patent No. 6,343,513)

John H. Cantrell and William T. Yost, Langley Research Center

Non-destructive evaluation of materials involves inspecting the materials without having to damage them or dismantle structures to which the materials are incorporated. Known methods of fatigue damage detection include bombarding the material under test with acoustic finite amplitude waves and examining the response waves produced by the material to determine a nonlinearity parameter, which may be correlated to material fatigue. This method cannot detect material damage such as internal cracks.

This invention is a method of measuring acoustic nonlinearity in materials by generating and applying an acoustic signal to a reference material having a known acoustic nonlinearity parameter, and applying an output signal from the reference material and derived from the acoustic signal generated in the first step to at least one environmentally controlled bandpass amplifier. The method also compares the outputs of the bandpass amplifiers, and based upon the comparison, determines the acoustic nonlinearity parameter of the sample material.

Phenylethynyl Containing Reactive Additives

(U.S. Patent No. 6,350,817)

John W. Connell, Paul M. Hergenrother, and Joseph G. Smith, Jr., Langley Research Center

A variety of monomers, oligomers, and polymers containing ethynyl and substituted ethynyl material groups are used to prepare coatings, moldings, adhesives, and composites. These materials exhibit a good combination of physical and mechanical properties. There exists, however, a need for high-temperature resins that can be processed at low pressures and without an autoclave.

This invention provides novel phenylethynyl-containing reactive additives that can be used with any phenylethynyl-containing polymer, co-polymer, oligomers, or co-oligomers to decrease melt flow and processing pressures required to fabricate molded parts, adhesive bonds, and fiber-reinforced composite parts.

These qualities can be obtained by synthesizing amide acid and imide phenylethynyl reactive additives, and adding them to phenylethynyl-containing polymers, co-polymers, oligomers, and co-oligomers in solution or by mixing dry imide powder of the reactive additive with phenylethynyl-containing oligomer powder.

For more information on the inventions described here, contact the appropriate NASA Field Center's Commercial Technology Office. See page 12 for a list of office contacts.

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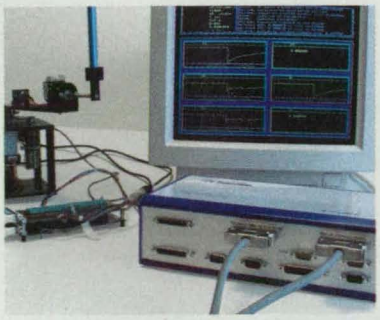

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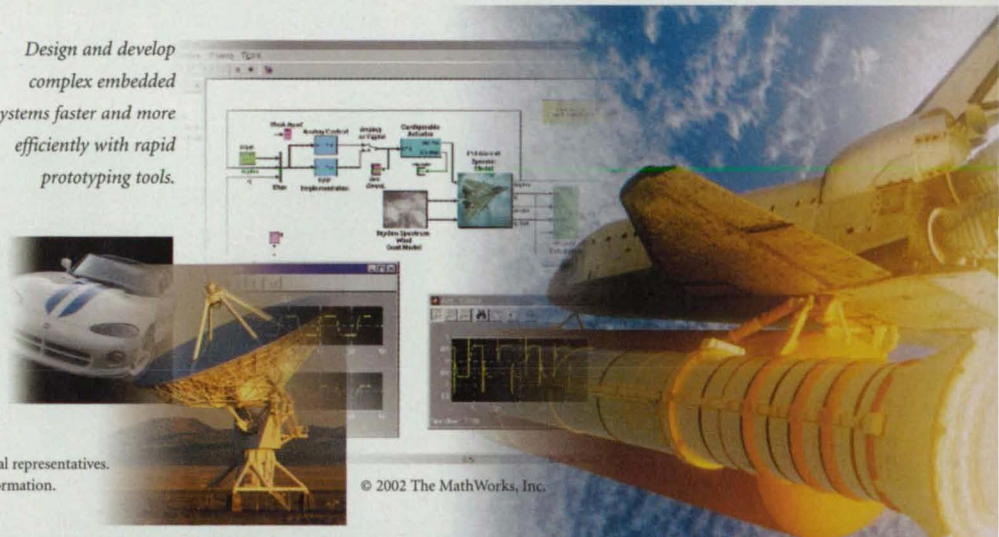

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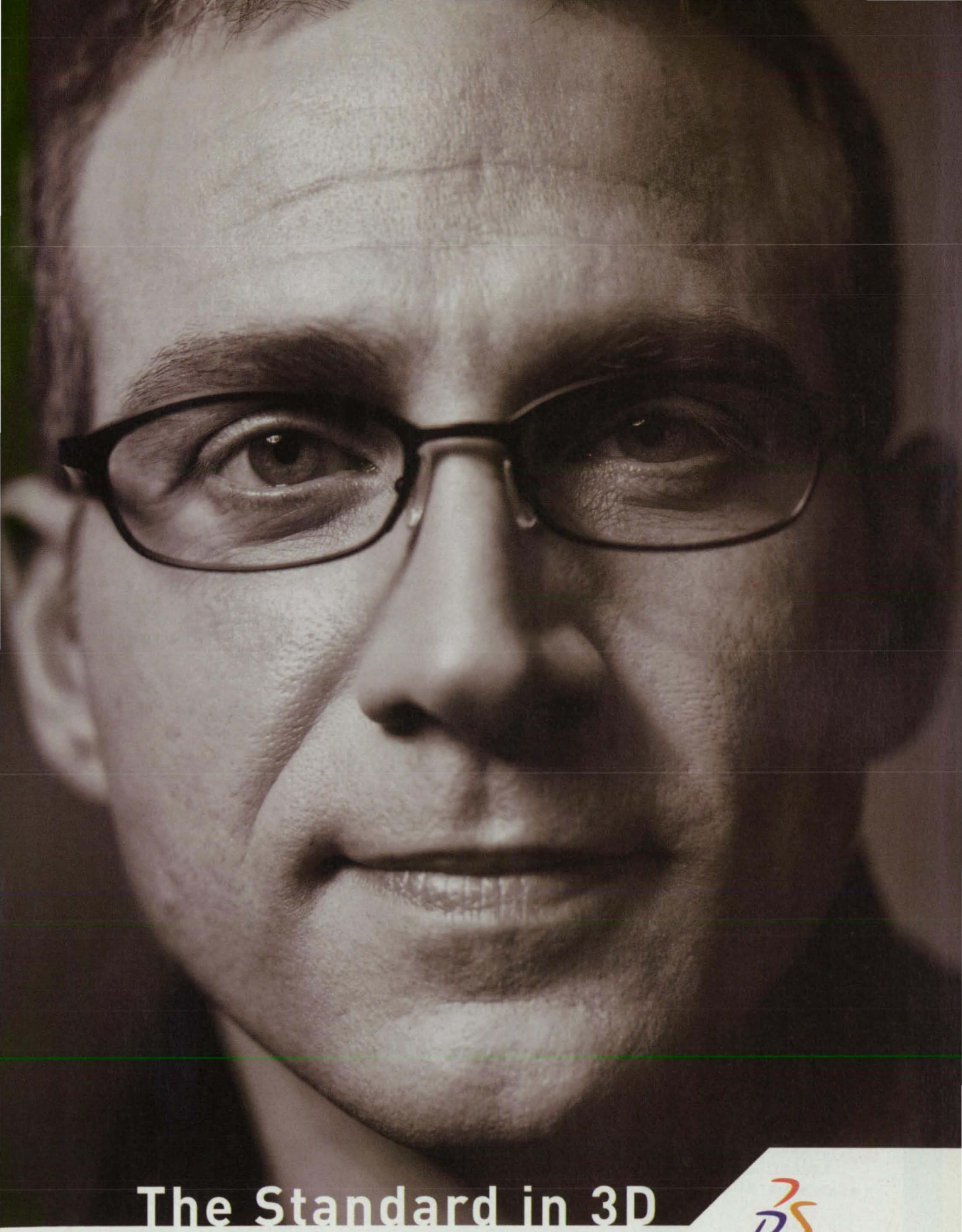

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Amy Keith, Remedial Project Manager for CERCLA, Marshall Space Flight Center

Amy Keith is an environmental engineer and the Remedial Project Manager for CERCLA (The Comprehensive Environmental Response, Compensation, and Liability Act) at NASA's Marshall Space Flight Center in Huntsville, AL. She is part of a team that is helping to clean-up ground water pollutants at Marshall.

***NASA Tech Briefs:* What types of projects are you involved with as an environmental engineer at Marshall Space Flight Center?**

Amy Keith: We are involved in cleaning up 69 CERCLA sites. We work with the EPA and the Alabama Department of Environmental Management to get these sites evaluated and determine if they need to be cleaned up. We also evaluate what clean-up technology we will use.

NTB: Marshall is known for its expertise in manufacturing, microgravity processing, and space propulsion. How did the center become involved in environmental research and safety?

Keith: Prior to being listed as a Superfund site, Marshall Space Flight Center conducted a preliminary assessment to determine if we had sites that required remediation in 1998 and a facility investigation under the RCRA (Resource Conservation and Recovery Act) program in 1993. Marshall Space Flight Center was listed on the National Priorities List of Superfund Sites in May of 1994. The EPA designated 69 sites as potentially contaminated, and as a Superfund site we were required under CERCLA law to investigate. Most of the contamination that we are cleaning up was due to work that was done in the 1950s and 1960s. Rocket engine testing in the 1960s used solvents such as trichloroethene and perchloroethene to clean the nozzles of the engines after testing. These solvents traveled through the soil and into the ground water.

NTB: What environmental safety projects are currently being evaluated at Marshall?

Keith: We are working on groundwater treatability studies. Treatability studies test technologies to see how well they will clean up a certain site with certain contaminants. Right now we are monitoring a technology that we used to clean trichloroethene from groundwater. Because of the low permeability clays here, it is difficult to inject chemicals *in situ* and achieve contact with contaminants. We injected zero-valent iron into the ground water using an innovative injection system. Typically, clean-up reagents are injected using only gravity feed-systems. The injection mechanism we used is innovative in that it atomizes the zero-valent iron and causes it to penetrate the soil resulting in better contact between the zero-valent iron and the contaminants. We've had good results so far; up to a 95% removal of trichloroethene from ground water.

NTB: What kind of response has this technology received?

Keith: This project was nominated by the EPA for presentation at the NATO committee on the Challenges of Modern Society meeting that was held in Rome in May of this year. There were 20 countries there, some of which asked for additional information. We hope to be able to share that information with them.

NTB: Do you foresee any of these technologies having an impact on future environmental issues?

Keith: The technology that we are using, particularly the zero-valent iron, is a well-known remediation technique for cleaning up volatile organics in ground water. What is innovative about our technology is the delivery system. We think that this delivery system will aid other places in the country and in the world that have low-permeability soils and have a difficult time getting their reagents to come in contact with the contaminant.

A full transcript of this interview appears on-line at ***www.nasatech.com/whoswho****. Amy Keith can be reached at Amy.Keith@msfc.nasa.gov.*

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Computer Simulation Software Used to Evaluate Actuators for Next Generation Space Telescope

OPERA-2D finite-element-based electromagnetic analysis program
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Aurora, IL
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www.vectorfields.com

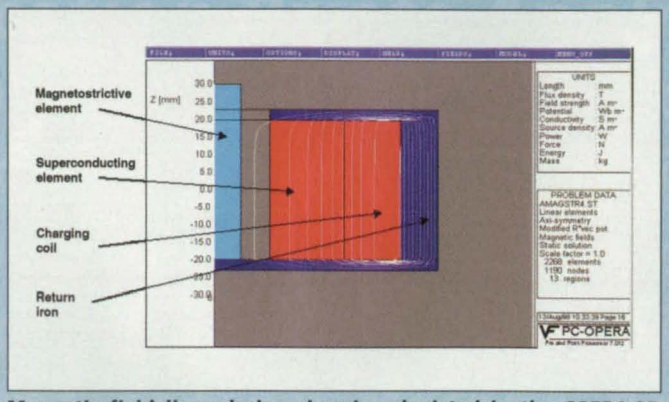
The Hubble Space Telescope will be retired at the end of this decade and will be replaced by the Next Generation Space Telescope (NGST). As part of NASA's Origins program, NGST is designed to study the first stars and galaxies that formed after the universe cooled. The NGST's mirrors will be thin membranes consisting of carbon composites for structure, and a reflecting surface. The mirrors are deformable, and computer-controlled actuators will be used to adjust their shape to ensure high-quality, sharp images.

One of the most critical design challenges is the environment in which the actuators must operate. Because the NGST is designed to work in the infrared range, the detectors and optics must be as cold as possible. Excess heat from a telescope can cause background noise in images and spectra. For this reason, the NGST will be placed in a fairly distant orbit where the temperature is expected to be between 30 and 100 degrees Kelvin. Unfortunately, no existing actuators are capable of delivering the necessary level of control while operating in those temperatures.

The monolithic BSCCO actuator design.

As a result, NASA researchers had to develop new actuators. Massachusetts Institute of Technology (MIT) in Cambridge, MA, collaborated with NASA on the development of actuators based on superconducting and magnetostrictive materials. Leslie Bromberg, principal research scientist at MIT, evaluated two different actuator designs. The first charged high-temperature superconducting materials such as yttrium-barium-copper-oxygen (YBCO) or bismuth-strontium-calcium-copper-oxygen (BSCCO) with a magnetic field. The resulting force attracts a reflective surface made of magnetic material such as nickel. The second concept was based on magnetostriction, the process by which a ferromagnetic material transforms from one shape to another in the presence of a magnetic field.

With the first concept, scientists needed to ensure that the superconducting actuators would maintain a given strain field in the mirror membrane after they were charged. A number of design variables affecting force generation had to be determined, including the voltage and current for the charging



Magnetic field lines during charging depicted in the OPERA-2D software.

coil, the thickness and length of the superconducting material, the amount of current that would be applied to the material, and the size of shielding surrounding it.

Instead of resolving the performance of the actuators experimentally, Bromberg and his colleagues decided to simulate the performance using software. Using OPERA-2D finite-element-based electromagnetic analysis program from Vector Fields, "We could run a simulation, see how the field behaved, then go back and change the design and run the simulation again," said Bromberg. "This way, we would have time to assemble the right combination of design variables to deliver the right amount of force."

He began the simulation by modeling the geometry of the actuator as a two-dimensional cylindrically symmetric cross section using the software's CAD facilities. For both design concepts, the model included common features such as the reflective membrane, the charging coil, and shielding. The program divided the model into finite elements. Bromberg then ran the solver, which predicted the magnetic field. The simulation provided graphical output including graphs and histograms of the solution and contour plots that showed the magnetic field values superimposed on the 2D model.

Using this information, the scientists adjusted the various design parameters to obtain the desired level of magnetic force for both design concepts. As they changed the design, they were able to optimize issues such as the placement of shielding material because the results allowed them to see the interaction of the magnetic force with the shields.

"The beauty of using electromagnetic analysis software was that by the time we built the actuators, we knew that both designs generated the level of magnetic force they were supposed to," Bromberg said. "We wouldn't have had that certainty otherwise."

The final designs were built and tested at MIT, and the technology was transferred to NASA, which will conduct additional tests at the Jet Propulsion Laboratory's Cryogenic Actuator Test Facility in Pasadena, CA.

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Technologies of the Month

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Smart Card Technology for Mobile Storage Applications

Bayer AG

Optical memory cards typically handled high-capacity mobile storage, but the relatively large size and high cost of the read/write components necessary to store and retrieve information limited their use as a personal device.

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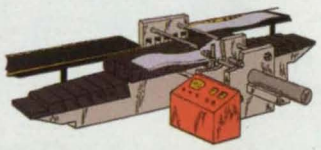
Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/bayerAG.html
Email: nasatech@yet2.com
Phone: 617-557-3837

Metallurgy Reduces Steel Product Cost and Weight While Improving Strength

Caterpillar

The strength of a welded fabrication usually is determined by the strength of a welded joint, and typically, structures are based on fatigue limits of joints. A good joint requires extra material, meaning that many products constructed of welded steel plating are much heavier, bulkier, and more expensive than they need to be. Caterpillar has discovered two ways around this problem.



The first process enables intermittently spaced, thickened areas along metal plate edges, resulting in metal plates that can be fabricated with variable edge thickness designed to coincide with the weld requirements of any particular spot. The second solution allows for weld geometries to be reproduced during manufacture by controlling the weld wire, weld parameter, and steel fit-up. These processes have been employed on nine different production applications and have resulted in up to ten percent weight reduction, and three to ten times improvement in fatigue life.

Get the complete report on this technology at:
www.nasatech.com/techsearch/tow/caterpillar-metallurgy.html
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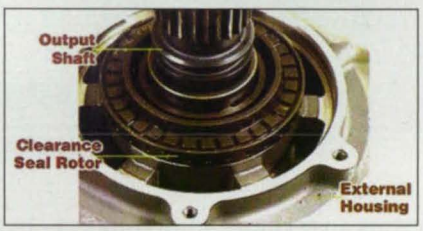
Non-Contact Rotary Fluid or Oil Seal Reduces Shaft Wear and Failure

Honeywell

Mechanical seals are prone to wear and may have resulting oil leakage. Honeywell has developed a non-contact sealing technology that uses centrifugal force to circulate oil or other fluids away from potentially leaky areas and back into a bearing housing without physical contact between a seal member and the rotating shaft.

Utilizing a slinger rotor mounted onto the shaft near the inside of the bearing housing end wall, the high-speed rotation of the shaft drives the lubricant into a circumferential array of ports contained in a radial ring on the rotor. A lubricant-air separation is created, driving the lubricant into the slinger ports for redistribution inside the bearing housing. This technology reduces heat generation, maintenance downtime and expenses, prevents leaks, and increases shaft lifespan.



Get the complete report on this technology at:
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Coupling Technology Simplifies Glass Fiber-to-Chip Interconnects

Robert Bosch GmbH

Today's high-speed, high-bandwidth data and communications systems are using increasing numbers of passive waveguide devices requiring precision interconnects between glass fibers and board-level components. What makes these interconnects so tricky are the different diameters of the fiber and the waveguide, which can cause a lateral displacement.

By filling the alignment V-grooves on a micromachined silicon-substrate with plastic materials and coating the chip with an optically transparent polymer, the waveguides can be fabricated with the precision of standard photomask technology. An excimer laser is used to remove the polymer filler from the trenches so that the fibers can be passively aligned with the necessary precision.

Get the complete report on this technology at:
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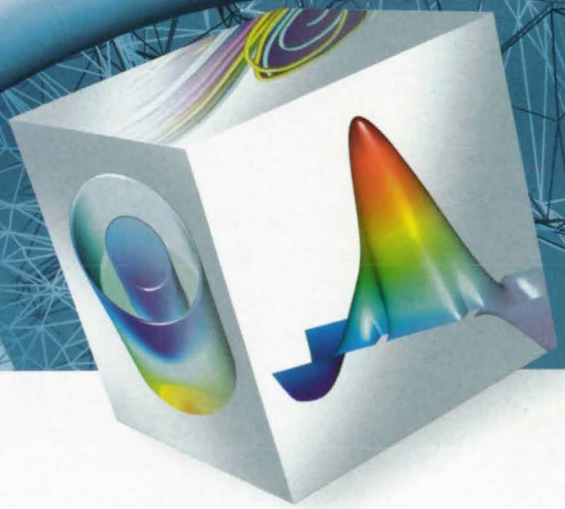

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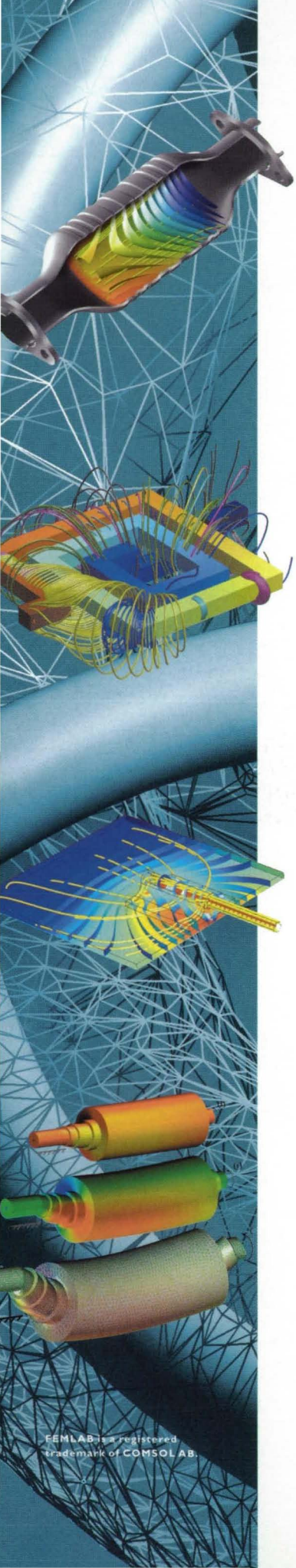

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The most common reactor for environmental protection, which we encounter or use everyday, is the catalytic converter in automobiles. In these monolithic catalysts, carbon monoxide and nitrous oxides are converted into relatively harmless species like carbon dioxide and nitrogen. To optimize the utilization of the expensive catalyst, it is important to be able to model the reactor at different operational conditions. In this FEMLAB model, mass and heat balances are coupled to compute temperature distribution and flowlines in the reactor.

This square-shaped spiral inductor is used for bandpass filters in micro electromechanical systems (MEMS). The FEMLAB simulation takes the nonuniform current density in the coils into account to compute an accurate magnetic flux arround the coils. The inductance of this inductor is 2.1 nH, which is obtained by integrating the magnetic energy. Using the programming language of FEMLAB for parametric analysis, you can find the correlation between the induction and the input parameters of the model.

In the design of electrodes for water electrolysis, it is important to minimize the voltage losses at a given total current. FEMLAB modeling helps the engineer in the design of the electrode geometry and the current collector. The model gives the current density distribution and the potential distribution in the system. These results make it possible to avoid excessive degradation of the active electrode surface and overheating of the welds at the position of the current collector.

When designing an electric motor it is important to design the rotor shaft so that no eigenfrequencies exist in the working range of the rotational speed. It is also important to study the shape of the eigenmode and not just the eigenfrequencies. In the eigenfrequency analysis, one end of the shaft is fixed and the other end is free to rotate and axially deform. The image shows deformation and rotation angle in the second eigenmode, using different visualization options like colormaps and scaling.

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Next-Generation Computer Hardware: The Engineer's Most Powerful Tool

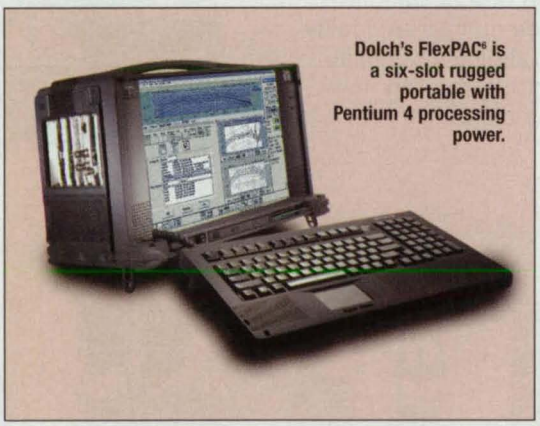
With new choices in both desktop and portable computing, engineers are becoming more productive in the office and in the field.

Whether you're a design engineer using a high-end desktop workstation, or a field engineer using a laptop or rugged portable system, today's computer hardware offers more choices in form factor, processing power, and mobility for the engineering community than ever before. Ultra-powerful chipsets and integrated wireless connectivity are also contributing to the widespread computerization of engineers.

As engineers need to focus on more complex applications, the computers they use also need to evolve. In the recent past, many applications in computer-aided design and manufacturing (CAD/CAM) were not even possible on anything but a desktop workstation. Now, with more powerful portables, performance is no longer a barrier to mobile computing.

The mobility of the engineering workforce mirrors what has happened in most other work environments — the use of multiple portable devices that can keep workers working 24 hours a day. "We all have cell phones and mobile systems, and we take our work with us everywhere," said Bob Lenard, IBM's brand manager for IntelliStation for the Americas. "There is a mobile revolution coming about that is affecting engineers."

"The computerization of the field workforce is increasing, and is the biggest and fastest-growing segment of the marketplace," according to Dale Szymborski, president of Kontron Mobile Computing, a maker of rugged portable computers. "The mobile workforce has changed. They no longer can live without having a computer."



Dolch's FlexPAC® is a six-slot rugged portable with Pentium 4 processing power.

Intel, for example, has focused a great deal of research and money on the high-performance mobile computer market. The availability of new software, utilities, and operating systems that efficiently use high-performance processors are making mobile computing a viable alternative to desktop systems. In fact, Intel offers the Mobile Intel® Pentium® III processor specifically for portable PCs.

"The processing power of the mobile field computer is getting closer to desktop power," said Szymborski. "As soon as remote power sources can keep up with the Intel processor's power consumption, you'll see the gap closing even further between mobile and desktop performance," he added.

IBM recently finalized its plan for advancing technology in the mobile workstation area for engineers. The new mobile workstations incorporate high-performance 3D graphics in a battery-powered notebook form factor. "The mobile workstation in one form is available today," said John Holz, IBM's vice president and business line executive for E-Server IntelliStation

The ReVolution, from Kontron Mobile Computing, converts from a notebook to a tablet via a 180° hinge.

Workstations, referring to the ThinkPad A Series portable. The new portables will, in essence, function as mobile IntelliStations, allowing engineers to take their workstations with them wherever they go.

Tough Enough?

One of the fastest-growing markets in the mobile computer hardware field is rugged portables. These systems offer the field engineer desktop power, but with the added benefits of resistance to shock, vibration, water, dust, dirt, and other harsh environmental conditions that standard laptop computers don't provide. Many of these units meet military specifications and can be outfitted with expansion cards, detachable keyboards and mice, integrated color printers, and wireless data communications capabilities.

With such recent technological advances, rugged computers have expanded their application from in-vehicle and factory shop floor uses into areas such as remote video conferenc-

IBM's ThinkPad A Series marks the first generation of the company's upcoming mobile workstations.

ing, telemedicine, auto manufacturing, telecommunications, and many other industrial settings, according to a report by Frost & Sullivan. In all of these applications, the demand for real-time information to a remote site is critical, so integrated communications systems are becoming a priority when selecting rugged computers.

(Continued on page 30)

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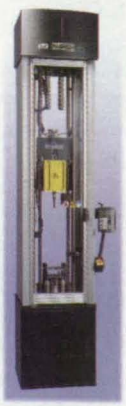

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As with any mobile device, power consumption is a prime consideration. Battery systems and other power-hungry components must be designed in a low-cost way for mobile computers, said Szymborski. "There are many different projects that are ongoing to try to solve the problem of energy density. It's at least five to ten years away before we see the next major development in battery technology," he predicted.

"Current technologies — fuel cells and using nanotechnology to make the power systems more effective and remove heat — are pressed as far as they can go today," Szymborski added. "There are very encouraging new technologies, but it's a matter of being able to put them into production at a low cost."

Kontron, with its latest product offering, has combined the rugged portable market with the burgeoning tablet PC market to produce the ReVolution, a system that incorporates both. The Windows-compatible rugged computer converts from a notebook to a tablet via a 180° hinge.

Other manufacturers of rugged portables, such as Dolch Computer Systems and Broadax Systems Inc. (BSI) also are providing engineers with powerful "workhorse" units that continue to be upgraded with the highest processing power available. Dolch, which focuses on test and measurement applications in the field, offers portable PCs that range from lightweight mobile attaché-type models to large-screen, multi-slot systems such as the FlexPAC^6, a rugged portable with Pentium 4 processing power.

BSI's offerings, which focus primarily on data acquisition, also include portable computers and workstations equipped with up to Pentium 4 power.

The i-Link Workstation from BSI is an all-aluminum, expandable rugged workstation.

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The company's newest offering, the i-Link Workstation, uses dual Pentium III processors, and is expandable through the use of removable drives.

Raising the Bar

The continuing improvements to workstations are driven by the advent of more and better graphics capabilities, sophisticated software, and low-cost applications supported under Windows. "In engineering, the emphasis is placed on improved design and analysis prior to products being manufactured," said Lenard. "The whole idea of electronic product design and analysis is the standard for the industry today.

"You have engineers who previously could not afford a CAD or analysis application to do what they needed to do," Lenard continued. "Now they can afford it, and they have better tools to attack the problems they're faced with. As a vendor, we take those latest and greatest products in terms of processors and graphics, and put them into systems that take advantage of the improved software."

For design engineers who require a powerful, high-performance workstation to run a CAD or analysis program, there isn't a better time to find a myriad of choices. Hewlett Packard, for example, recently released workstations based on the 64-bit Itanium® 2 processors that were co-developed with Intel. The HP Workstation zx2000 and zx6000 will enable users to choose their 64-bit operating system from Windows®, Linux®, or HP-UX (UNIX).

Targeted to the mechanical CAD and other graphics-heavy applications, these workstations give users who change operating systems the ability to use the same hardware. HP also continues to offer Compaq workstations to its engineering users.

Both high-end workstations and more powerful portables enable more distributed engineering. Real-time collaboration, for example, is now possible whether engineers are in the office or in another time zone. With the added advantage of new wireless connectivity options and networks, collaboration will continue to grow as a technology. Computer hardware vendors have only scratched the surface of what will be possible for engineering users in the near future.

"We view engineering as a market space that will continue to have exciting possibilities," said Lenard. "It will probably drive some of the most leading-edge applications of technology as we go forward."

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Methods and Software for Mining Data in Context

Ames Research Center, Moffett Field, California

The Perilog methods and software provide a suite of data-mining tools. Perilog retrieves and organizes data from any sequence of terms that are contextually associated (e.g., text, music, genetic sequences). Perilog data mining includes: (1) keyterm-in-context search; (2) flexible, model-based phrase search; (3) model-based phrase generation; and (4) narrative-based phrase discovery. The methods and software measure the degree of contextual association for large numbers of paired terms to produce models that capture the structures of the sequences of terms. Perilog compares these models to a query model, develops a ranking, and presents the results of the search to the user. It can also extract phrases from the sequences. Perilog was originally designed to support the Aviation Safety Reporting System, which NASA operates for the Federal Aviation Administration. In that application it produced, from a database of tens of thousands of documents, the first quantitative evidence of situational relationships between reported commercial aviation incidents and a specific type of aviation accident. Perilog can be used to mine databases for any type of information.

The Perilog methods and software were created by Michael McGreevy of **Ames Research Center**. *This technology is available for commercial licensing. For further information, access http://ettc.usc.edu/ames/perilog/homepage.html.*

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14512/3/4/5.

Beacon-Based Exception Analysis for Multimissions

Automated diagnosis is advanced using several novel signal processing approaches.

NASA's Jet Propulsion Laboratory, Pasadena, California

BEAM is a method of real-time, automated analysis and diagnosis applicable to a broad class of complex electromechanical systems, including spacecraft, aircraft, and process-control systems. Some aspects of its operation were described in "Reusable Software for Autonomous Diagnosis of Complex Systems" (NPO-20803), *NASA Tech Briefs*, Vol. 26, No. 3 (March 2002), page 33. Presented here is an expanded overview of the method, outlining its components and their function.

BEAM was conceived to accelerate diagnosis and to relieve human operators and ground control computers of the burden of diagnostic data collection and analysis. This is performed through a real-time fusion and analysis of system observables, including not only performance and sensor data but also knowledge of executing software and commands sent to the system. In the case of a spacecraft, BEAM would enable onboard identification of anomalous conditions, thereby obviating the need to telemeter large quantities of sensor information.

The BEAM formalism is based upon a reduction of the observables in a complex physical system to a compact set of coupled critical observables, which are tracked to analyze the state (or "health") of the system in real time. The coupled observables determine the information space of the physical system, and monitoring its invariants allows all events, responses, deterioration, anomalies, and failures to be detected and isolated with high precision. In contrast to classical model-based approaches in which one either (1) attempts to explicitly compare observed data to model predictions, or (2) relies upon a coarse operating envelope in the form of redlines, BEAM is highly adaptable and sensitive to complex nonlinear behaviors indicative of such faults.

The mathematical foundation of BEAM includes the following building blocks:

- The System Invariance Estimator (SIE) automatically constructs fundamental information invariants from multichannel data. Comparison of the invariants allows system diagnosis, identifies which observables are significant, and quantifies deviation and dependency between events.
- The Channel Coupling Operator (CCO) provides an embedded, algorithmically constructed means of relating sensed transitions and commands. This permits oversight of software executing in conjunction with the sensed hardware.
- The Data Fusion Operator (DFO) determines the proper combinations of observables to provide an instantaneous estimate of the system information state. This estimate serves as a single, event-based, health metric.
- The Variable-Fidelity Discontinuity Operator (VDO) utilizes an adaptive wavelet transformation to detect and amplify the onset of transitions or incipient faults. This operator is a highly sensitive means of performing single-channel analysis that is adaptable to very short or very long event periods.
- The Operating Map and Back-Projection Operator (BPO) represent the downlink and reconstruction elements of BEAM. The first is a compact parameter set based upon the other modules, which efficiently encapsulates specific features of fault events. This information is expanded by the BPO to allow causal reconstruction of the anomaly track.

These modules are applicable to nearly any system and can be trained using brief examples or approximations of nominal operating data. In combination these

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modules permit system analysis at the local and global level, and are responsive to hard faults, incipient faults, and anomalies that lie beyond the training envelope. BEAM is intended to reduce or eliminate the need for external diagnosis but also provide capability for autonomous detection and isolation of faults and degradation.

This work was done by Sandeep Gulati and Ryan Mackey of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Information Sciences category.*

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Refer to NPO-20827, volume and number of this NASA Tech Briefs *issue, and the page number.*

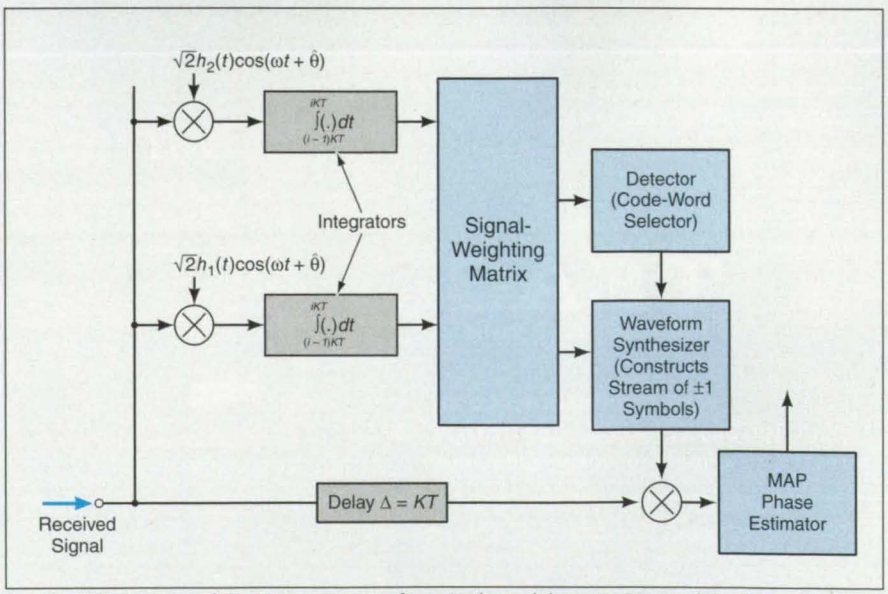
Generalized Pre-Processor for Block and Convolutional Codes

The design could be simplified by taking advantage of the structures of the codes.

NASA's Jet Propulsion Laboratory, Pasadena, California

A generalized data processor, proposed for use in the reception of binary-phase-shift-keyed (BPSK) radio signals, provides preliminary estimates of the block and convolutionally encoded symbols that are meant to be conveyed by the BPSK modulation. In a process denoted information-reduced maximum *a posteriori* (MAP) phase estimation, an estimate of the instantaneous symbol (and thus of the instantaneous phase modulation) is used to reduce the amount of randomness and information by converting the received modulated carrier to an approximation of an unmodulated carrier. The resulting partially reconstructed carrier is then fed as input to a MAP phase estimator to improve phase-tracking performance. The basic principles of information-reduced MAP phase estimation were described in somewhat more detail in "Information-Reduced Carrier Synchronization for Coded PSK Operation at Low-SNR" (NPO-20261), *NASA Tech Briefs*, Vol. 22, No. 10 (October 1998), page 64.

A detailed description of the generalized pre-processor can be found in the TMO Progress Report 42-144, October 2000, "Generalized Pre-Processor for Block and Convolutionally Coded Signals." Here we present a brief summary of the generalized pre-processor (see figure), which makes use of the algebraic structures of block and convolutional codes. In the coherent mode of opera-



This **Simplified Version of the Pre-Processor** performs Hadamard decomposition and signal reconstruction.

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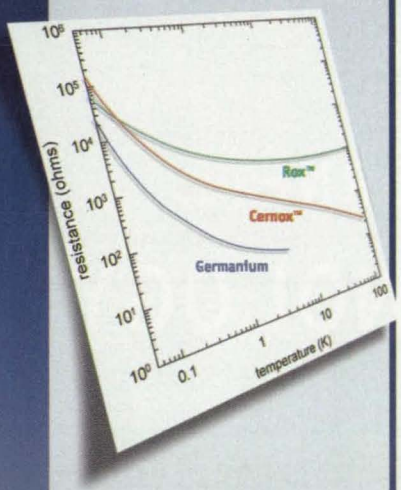

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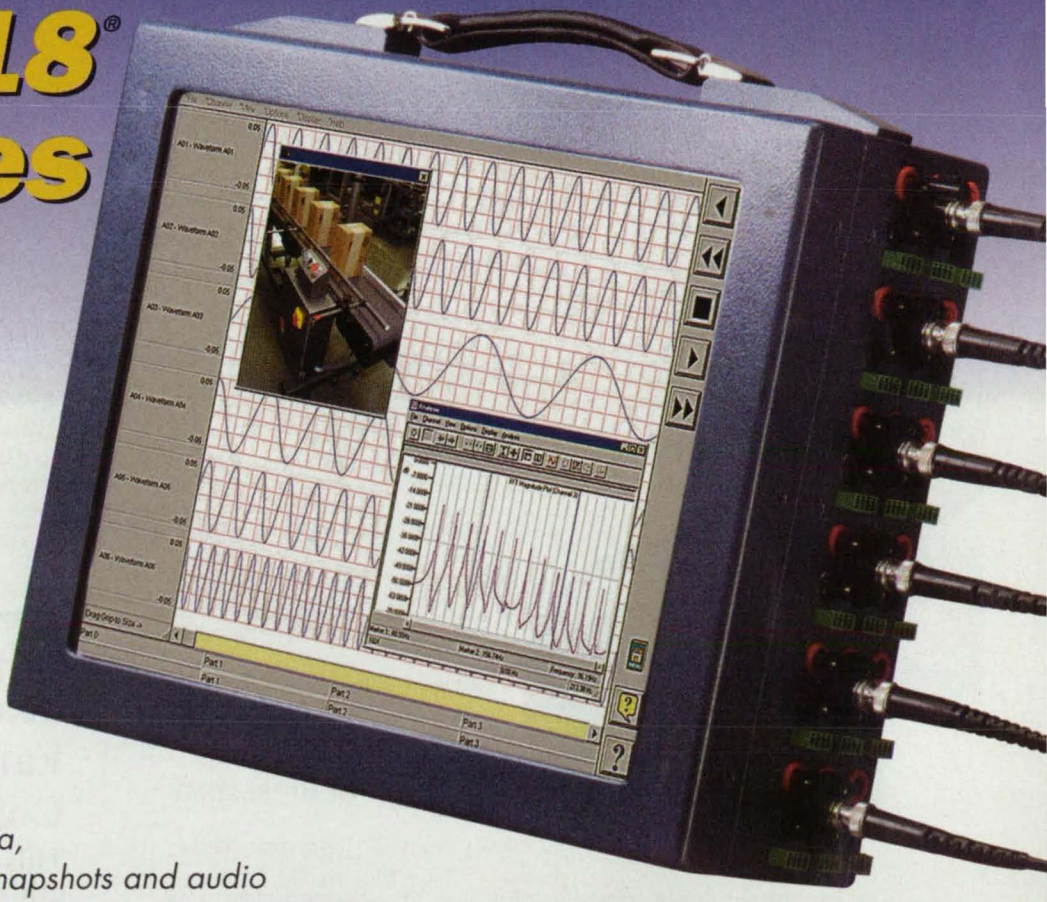

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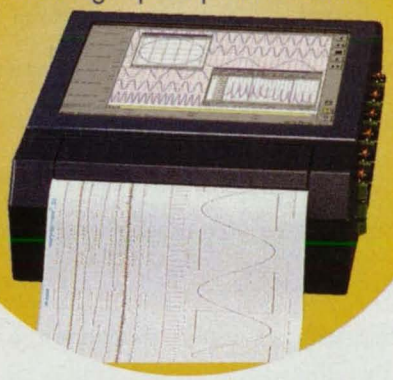

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tion, this pre-processor decomposes the received code words by use of orthogonal Hadamard basis functions and generates a vector of coefficients of length K (where K is the number of bits per code symbol) for each received block. Next, the coefficient vector is multiplied by a signal-weighting matrix to generate a vector of log-likelihood functions. The largest component of this decision vector is identified, and its index used to reconstruct the decoded code word.

The structure of the pre-processor remains essentially the same for any linear code of a given block length, except for the signal-weighting matrix, which is unique to each code. The signal-weighting matrix is pre-computed for each coding scheme by first generating the set of code words, then multiplying the Hadamard matrix by the coefficient matrix representing all possible code words.

The proposed generalized pre-processor was tested in computational simulations. The results showed that under representative conditions, including signal-to-noise ratios ranging from –5 to –10 dB, the increase in carrier-phase-estimation performance is equivalent to the improvement afforded by strengthening the received signal by 5 to 6 dB.

This work was done by Victor Vilnrotter, Clement Lee, and Norman Lay of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*

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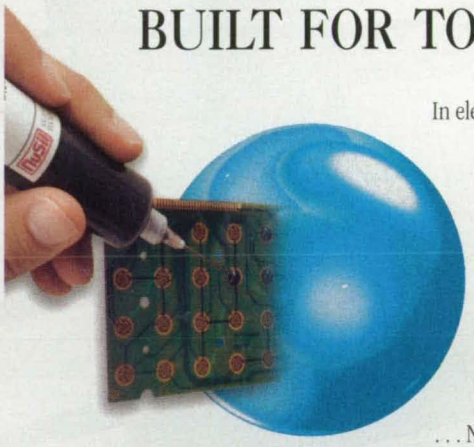

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Improved Transponder for Earth/Spacecraft Communication

This transponder utilizes advanced digital signal-processing techniques.

Lyndon B. Johnson Space Center, Houston, Texas

A prototype of a relatively inexpensive S-band transponder has been developed for use aboard a spacecraft as part of a NASA spacecraft tracking and data network (STDN). The transponder design incorporates recent advances in digital processing of received radio signals. Notable features of the design include flexibility in the choice of operating modes and "smart" acquisition of signals. The transponder design could also be adapted to military ground-based satellite communications and tracking and to commercial Earth/satellite communication systems.

The overall function of the transponder is to receive an S-band signal (uplink signal) from the ground, demodulate the signal to extract command and control information, and generate a return carrier signal modulated by either ranging or telemetry data to be transmitted back to the ground (downlink signal).

The STDN waveform comprises a binary-phase-shift-keyed (BPSK) subcar-

rier phase-modulated onto an S-band carrier. The transponder must phase-lock to the received uplink signal, determine frequency of the received carrier, and generate the return carrier signal at a frequency of exactly 240/221 times that of the received carrier signal.

The receiver portion of the transponder includes a flexible front end that enables selection of any of the STDN channels. An analog down-converter translates the S-band received signal to an intermediate frequency (IF) of ≈3 MHz in a noncoherent mode for in-phase and quadrature detection. An all-digital carrier-tracking loop coherently extracts the carrier from this IF signal. A field-programmable gate array is used to implement a carrier-tracking algorithm that supports operation of a first-, second-, or third-order phase-lock loop. The order of the loop can be changed by changing digital coefficients of a filter that is part of the loop. The return signal is translated from the IF to S band via a triple conversion process that maintains coherence between the received and transmitted carrier signals. An S-band linear phase modulator supports direct modulation of the return carrier signal.

Once the carrier has been extracted from the incoming signal, it is necessary to demodulate the subcarrier signal to extract the baseband signal that contains the command and control data; this involves subcarrier-lock and bit-synchronization operations that are performed by two commercially available application-specific integrated circuits that implement an all-digital early/late integrate-and-dump technique. The design of the transponder also incorporates an option to perform frame synchronization and Viterbi decoding. A commercially available digital signal processor performs frame-synchronization and system-control functions and serves as a communication interface with the host computer. Every system variable is editable via this transponder/computer interface.

One of the main features of the design is its ability to acquire the received carrier signal in the presence of modulation. This feature makes it unnecessary to perform a tedious acquisition exercise to lock the uplink and downlink prior to transmitting data. When, as sometimes happens, lock is lost, the transponder reacquires lock automatically. The transponder can also detect whether the carrier-tracking loop has locked to a sideband and, if so, can automatically correct the operation of the affected oscillators to cause the loop to lock on the desired uplink carrier signal.

This work was done by David Sanderlin of Shason Microwave Corp. for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*
MSC-23074

Analyzing Multispectral Signatures and Images of Biomaterials Through Neural Computing

Automated analysis can save time, reduce fatigue, and increase accuracy.

NASA's Jet Propulsion Laboratory, Pasadena, California

A method of semiautomated identification of biomaterials, now under development, is based on the use of a combination of neural-network and of self-organizing, molecular, and supervised-learning algorithms to analyze multispectral images. The method is especially applicable to such biomaterials as tissues and cells depicted in multispectral images of biopsy specimens. A basic premise of this method is that tissues and cells that are or may be malignant can be distinguished from healthy cells by morphological and molecular differences that manifest themselves as observable differences in multispectral images.

Heretofore, it has been necessary for a pathologist to look at all the cells in a biopsy specimen under a microscope in order to determine the degree of malignancy. This examination process is fatiguing, and most cells in a typical specimen are not malignant; as a result, the process is time-consuming and usually results in many errors. An automation method like this one could reduce examination time and fatigue while increasing the accuracy of diagnosis by quickly analyzing an entire specimen and identifying those portions of the specimen to which the pathologist's attention and expertise could be applied most productively.

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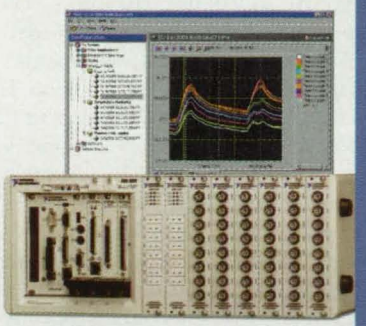

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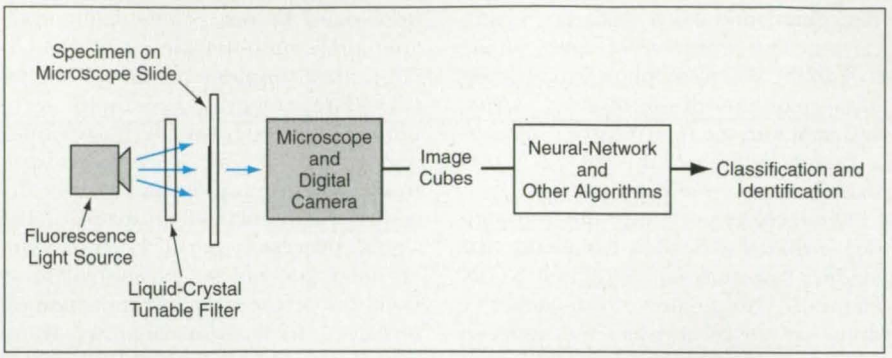
The figure depicts the major steps of the analysis process according to this method. A specimen is first placed on a microscope slide. Under an epifluorescence microscope, the specimen is exposed to light in a wavelength band selected by means of a liquid-crystal tunable filter. At present, transmission images of a specimen in approximately fifty 5-nm-wide wavelength bands that span the range from 470 to 710 nm. (In future versions, the wavelength range may be divided into a greater number of narrower bands.) The image in each wavelength band is detected and digitized (at present, to 12 bits for each pixel) by a monochrome digitizing electronic camera. The resulting multispectral image data can be represented as a stack of the images in the various wavelength bands: in the art of multispectral imaging, such a stack, or the data that it represents, is denoted an image cube.

For the purpose of identifying portions of an image that merit a pathologist's attention to determine the degree of malignancy, an image cube is processed by a number of algorithms, some of which implement artificial neural networks:

- The image cube is mathematically filtered to extract salient features, including sizes, shapes, and orientations of cell nuclei.
- The unsupervised-self-organizing attribute of neural networks is exploited to partition the image cube into classes based on similarities among spectral bands in the pixels.
- A combination of the self-organizing and supervised-learning attributes of neural networks is exploited to enable the use of a complex database of image cubes of known benign and malignant cells as a guide to further classification of unknown cells.

Development efforts have included the creation of a database of image cubes of known benign and cancerous human prostate cells. In tests thus far, the method as applied to image cubes of unknown prostate cells yielded correct classification in 98 percent of the cases.



Images of a Specimen are acquired in multiple spectral bands, then digitized, then processed by neural-network and other algorithms to identify portions that merit scrutiny by a human expert.

This work was done by Hamid S. Kohen of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Bio-Medical category.*
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Extending the Life of a Linear Tape-Open (LTO) Backup Tape

ALGOR, Inc., Pittsburgh, Pennsylvania

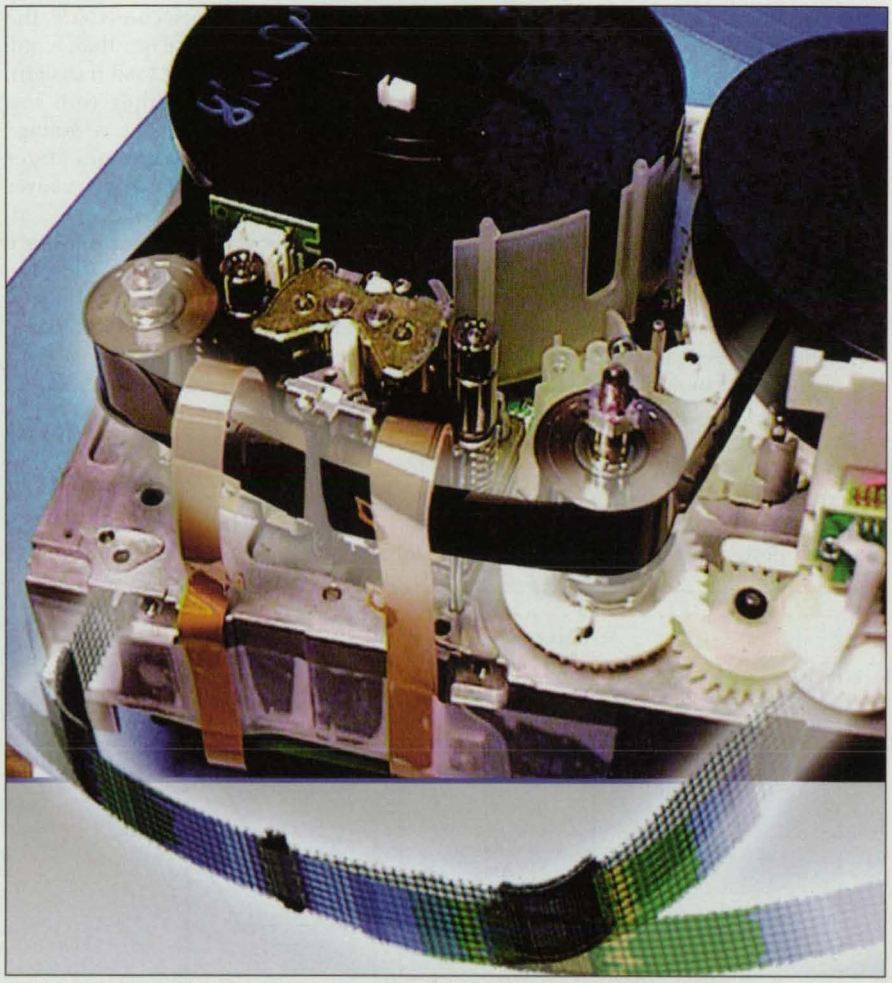
Data is any company's most valuable asset. Archiving systems are essential to ensuring that valuable data is preserved. A wide variety of technologies exists, but tape medium remains a popular choice for data backup due to its comparatively low cost and large capacity for data storage. Although tape drives are far from new, Linear Tape-Open (LTO) technology is a recent innovation that was developed jointly by Hewlett-Packard Company (HP), IBM, and Seagate. LTO replaces proprietary formats for corporate backup solutions with an open tape format, making it easier for customers to choose products.

Historically, the backup tape drive industry has been fragmented, and a proliferation of formats and technologies complicated customer buying decisions. LTO was defined as a best-of-breed, open tape format that can better serve multiple market needs and be supported by multiple suppliers through an open licensing process.

LTO maximizes capacity and performance by combining a linear, multichannel, bi-directional tape format already in common usage. It also adds enhancements in the areas of timing-based mechanisms, hardware data compression, optimized track layouts, and high-efficiency error correction code. Customers benefit from this format specification through the availability of multiple sources of product and tape cartridges, and common tape format specifications for interchange.

The Ultrium format from HP is a high-capacity, single-reel implementation of LTO, best suited for backup, restore, and archive applications for standalone and automated environments. Cartridges have a capacity of up to 200 GB.

In the process of designing tape drives to meet the LTO specifications, HP engineers conducted extensive analysis and testing to ensure that their product would stand out among available LTO drives for its reliability. In addition to extensive laboratory testing, HP used finite-element analysis (FEA)-based Mechanical Event Simulation (MES) software from ALGOR, Inc. to analyze the behavior of the magnetic recording tape as it is wound through the tape drive in order to find a way to reduce wear on the tape and increase durability.



Inside an **Ultrium Backup Tape Drive**, two rollers stabilize the tape as it is wound from a cartridge reel, across the tape heads, and into a take-up reel. The MES results, superimposed over the photo, show the stress in the tape as it is wrapped around the rollers and fed into the take-up reel.

The challenge was to optimize the LTO drive in order to increase tape durability while maintaining tape path stability. To study the tape's behavior, the software had to simulate motion, contact between parts in an assembly, large displacement, elastic material behavior, and stresses.

HP modeled the magnetic tape with isotropic shell elements and the drive assembly using kinematic elements. In the MES, the tape wraps around two rollers and across a tape head, and is then pulled into a take-up reel. The MES results showed the motion of the tape and resulting stresses. These results helped HP find a proprietary solution that keeps the tape on track while reducing stresses on its edge, thus extending the life of the backup tape.

This work was done by Paul Poorman of **Hewlett-Packard Company.** *Visit ltodrive.ALGOR.com to view the complete report. For more information on using* **ALGOR***'s finite element analysis products, contact ALGOR, Inc., 150 Beta Drive, Pittsburgh, PA 15238; Tel: 800-48-ALGOR; www.algor.com.*

Remote Sense Helps Power Sources Accurately Simulate Batteries and Charger Operation

The results are fewer false failure indications, more accurate device calibration, reduced product returns, and higher profitability.

Keithley Instruments, Inc., Cleveland, Ohio

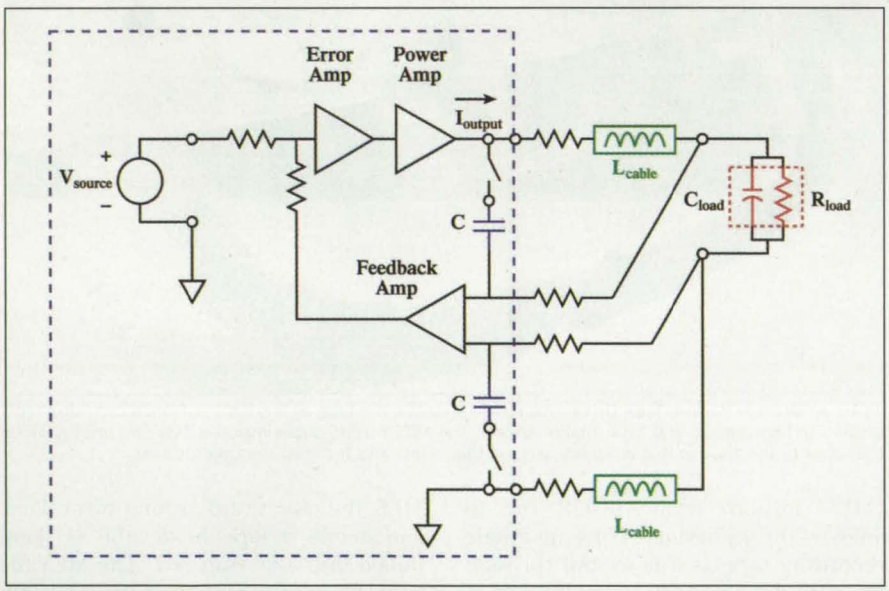
During development and production, cell phones and other portable devices must be tested and calibrated with a power source that accurately simulates battery operation. To avoid erroneous calibration and false failure indications in devices under test (DUTs), this generally requires a source with special characteristics. Besides low ripple and noise, it should be able to simulate different output impedances associated with various battery chemistries, charge states, and charger operation. Key features are remote sensing of load voltage, a variable compensation feedback loop, and superior open-loop response to load transients (see figure). The ability to detect an open sense lead also is desirable to avoid test set-up problems and potential DUT and test equipment damage.

Cell phones and other portable devices are designed for low power drain when they are in standby or sleep mode. They demand a burst of energy when transmitting, receiving, or performing other functions. When powered from a rechargeable battery, which typically has internal resistance in the range of 100-500mΩ when fully charged, the voltage at the DUT drops and stays down for the duration of the current (load) pulse. This is a product of internal resistance and load current.

In some applications, the rise and fall times of the voltage and current pulses are only tens of microseconds and the entire pulse width may be less than a millisecond. With such a fast load transient, a conventional power supply with less than 20kHz bandwidth has a voltage droop that is probably 100 times larger than a battery's, and does not recover until after the current pulse has ended. Therefore, conventional supplies are poor simulators of batteries; they are also ill-suited for simulating DUT operation under constant current or constant voltage charger operation.

The power source in a portable device test system may not be physically close to the load. If the source uses only local sense, the DC voltage drop in the power leads, which are part of the local sense feedback loop, can introduce voltage output errors. The solution is to use remote sense leads with a high input impedance feedback amplifier to minimize voltage drop and accurately sense voltage at the load (see figure). With appropriate design, the feedback loop can provide fine control of the power source output impedance, thereby simulating various battery types and charge states.

Typically, twisted pair cables are used for both the power and remote sense leads. Note that in the figure, the complete feedback loop is a reactive circuit when supplying pulsing loads. Combined with other loop elements, the remote sense feedback circuit must have a high (typically >1MHz) bandwidth for fast transient response, but cannot introduce instability.



Battery Simulation Power Source With Remote Sense Leads. Frequency compensation capacitors, C, are useful in some situations to improve power supply stability.

Power supply designers typically use a frequency domain Bode plot to determine when the open-loop phase angle is -180 degrees and open-loop gain is 0dbV. Both conditions must exist simultaneously for instability to occur. Mathematically speaking,

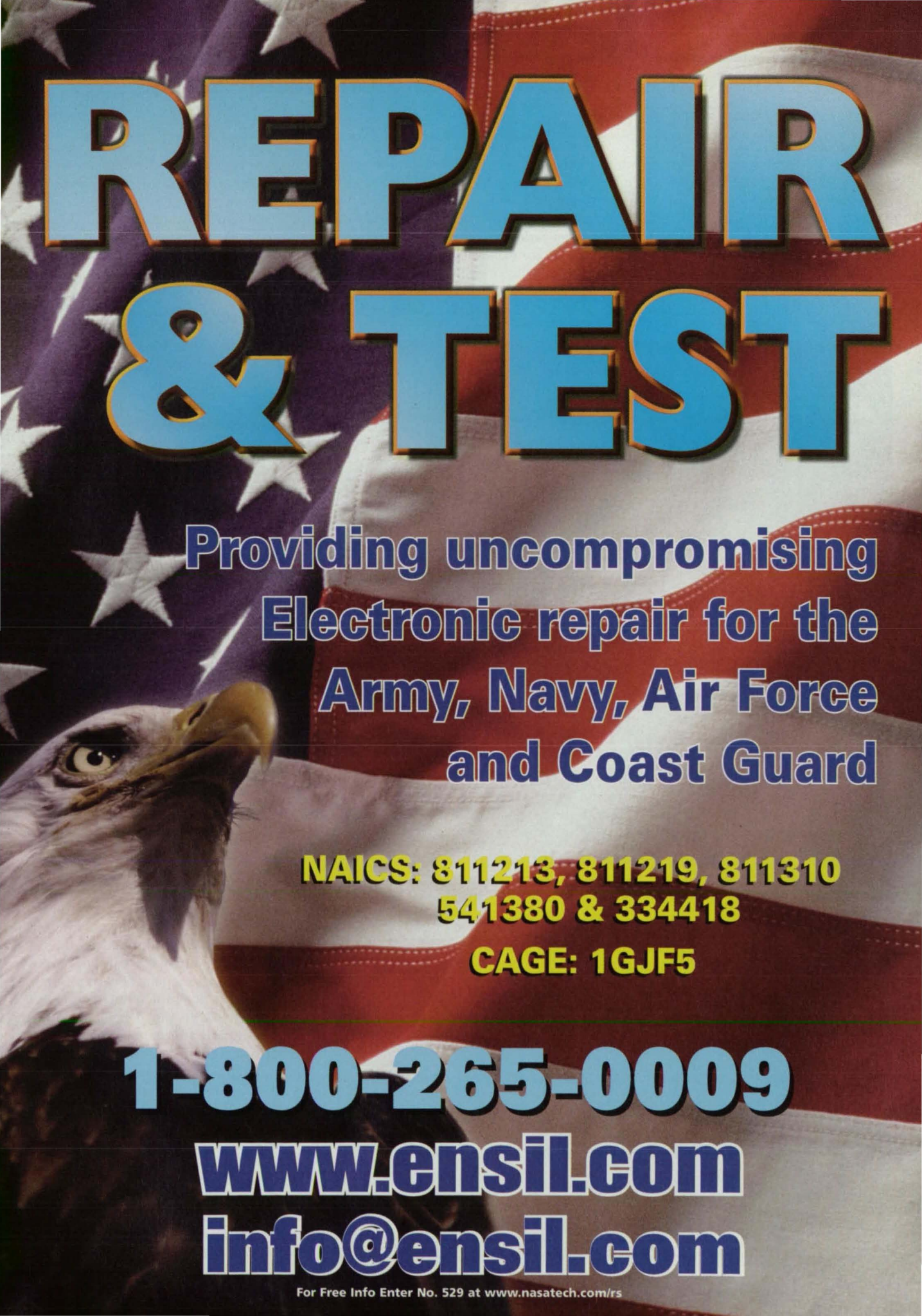
$$A_{\text{closed loop gain}} = \frac{A_{\text{forward gain}}}{\left(1 + A_{\text{forward gain}} \times B_{\text{feedback}}\right)}$$

AB must equal negative one for instability (oscillation) to occur.

These conditions are often expressed in term of phase margin and gain margin. Phase margin is the difference between -180 degrees and the phase angle when open-loop gain is 0dBV (|AB|=1), i.e., the change in open-loop phase shift required to make a closed-loop system unstable. It also measures the system's tolerance to time delay. Gain margin is the change in the amount by which the open-loop gain can be increased before system instability occurs. The goal is a control loop that is unconditionally stable for all values of gain and expected phase shifts created by loop elements. Given that load characteristics are largely unknown to general-purpose power supply designers, this is a tall order.

In some designs, if a remote sense lead is impaired, the power supply automatically defaults to local sensing. This can result in a voltage output error that is a serious problem for manufacturers using the power supply to calibrate the DUT's A/D converter, which monitors battery voltage. Erroneous calibration of the A/D converter with the wrong voltage can show up as a DUT failure during testing, even though nothing else is wrong. Realistic battery simulation, plus open sense lead detection, can prevent these problems, thereby lowering the frequency of retesting, rework, and product returns.

This article was written by Robert Green, Telecommunications Market Development Manager at **Keithley Instruments**. *For information, call 1-800-534-8453, or visit www.keithley.com.*



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Clamps for Testing Cable Shields and Connector Shells

John F. Kennedy Space Center, Florida

Connector test clamps (CTCs) are clamping electrical connectors designed for use in testing electrical continuity from the backshell of a connector at one end of a shielded electrical cable, through the cable shield, to the backshell at the other end of the cable. CTCs increase the reliability of testing of shielded electrical cables beyond that achievable with alligator clips (for which suitable attachment points often cannot be found). Each CTC consists of a conductive jaw mounted onto a manually operated ratcheting clamp that can be released by finger pressure on a lever. CTCs can be made with jaws of various sizes and shapes to fit a variety of connector shells or applications. Each CTC is machined to allow connection of a standard banana-jack-tipped test lead. Once the CTC is clamped into place, one end of the test lead is inserted into the jaw and the other into any type of test equipment required. CTCs can be utilized in any application where a standard alligator clip is not sufficient.

This work was done by Kenneth A. Reaume of United Space Alliance for **Kennedy Space Center**. *For further information, please contact Phil Restivo, 1150 Gemini Ave., M/S: USH-100 D, Houston, TX 77058, Tel. No. (321) 212-6125, E-mail: Philip.G.Restivo@USAHQ.UnitedSpaceAlliance.com*

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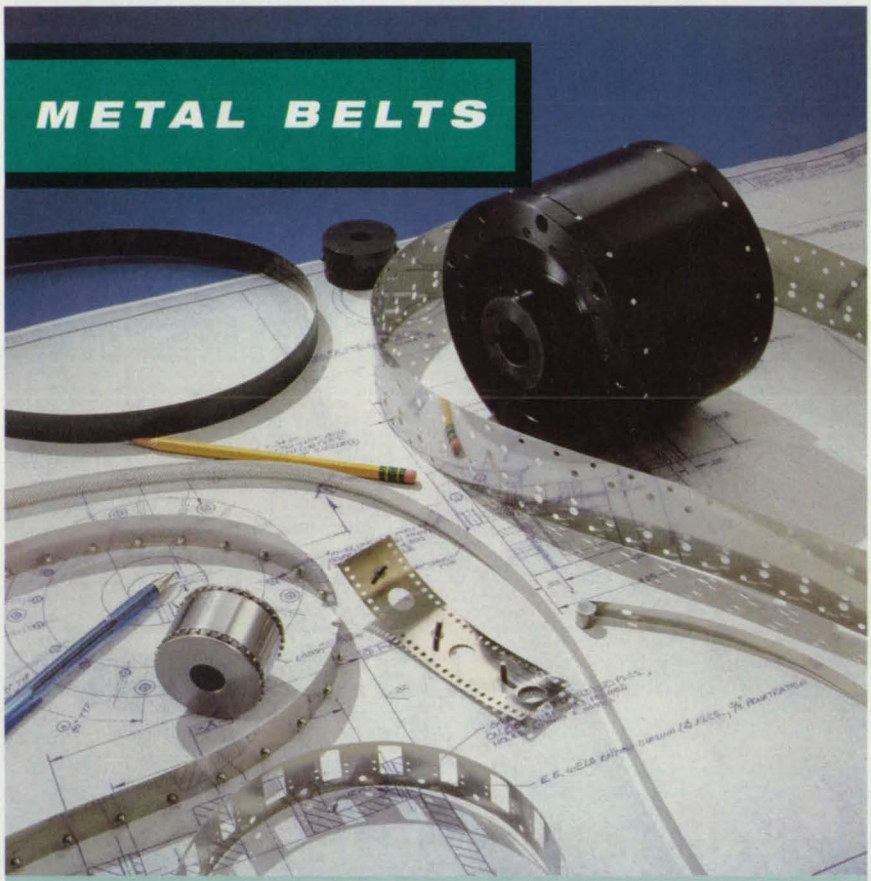

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Making Audible Alarms More Noticeable in Noisy Environments

Ames Research Center, Moffett Field, California

An improved method of generating audible alarms has been invented for stressful environments in which there may be considerable background noise and where the intended recipients of the alarms also need to pay attention to sounds other than the alarms. An aircraft cockpit is a typical example of such an environment. This method does not rely on a sustained loud alarm to attract attention because a loud alarm can be gratuitously startling and can mask other sounds that also demand attention. Instead, this method comprises the following elements: (1) The initial alert and subsequent reminders are given via short bursts of synthesized stereophonic signals with a spectrum sufficiently distinct from the noise spectrum to be noticeable. (2) Using pairs of earphones or loudspeakers to implement the stereophony, the alarm signal is made to appear to rapidly alternate between arrival from two different directions. (3) The alarm signal can be supplemented via stereophonic manipulation of background-noise signals.

This work was done by Durand R. Begault of **Ames Research Center**.

This invention is owned by NASA, and a patent application has been filed. Inquiries concerning nonexclusive or exclusive license for its commercial development should be addressed to the Patent Counsel, Ames Research Center, (650) 604-5104. Refer to ARC-14556.

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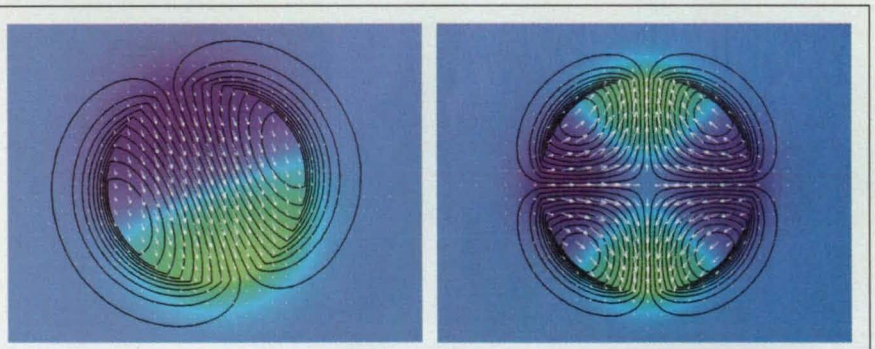
Design & Analysis of Photonic Devices:

Software Plays a Key Role in Overcoming Network Bottlenecks

The demand for ever-increasing bandwidth in communications networks is the driving force in the rapidly growing photonics industry. The development of low-loss optical fibers and wavelength division multiplexing techniques during the past decades has brought technology to a point where mere electronic switches and gates are the bottlenecks in communication systems. In the development of all-optical replacements for such electronic components, a combination of modeling and experiments is required.

Modeling of photonic devices involves the modeling of electromagnetic wave propagation in heterogeneous, anisotropic, nonlinear, dispersive, and lossy media. Material parameters typically depend on mechanical stresses and thermal conditions as well as electric and magnetic fields.



Mode analysis of a single step optical fiber made of silica glass. The full vector hybrid mode formulation computes the HE11 mode (left) and the HE21 mode (right) without inherent approximations. Here the axial field components Ez and Hz are plotted as color and contour plots, respectively. Arrows indicate the direction of the in-plane electric field.

Mode Analysis of Optical Fibers

One of the winning devices of modern communication systems has been the single mode silica glass (SiO_2) fiber, having a step index profile with a higher refractive index in the center core, and a lower index in the outer cladding. Numerical modeling is playing an important role in the design of single mode waveguides and fibers. In the figure, a single step index waveguide is studied. The inner core is made of pure silica glass with a refractive index of 1.4457 and the cladding is doped, with a refractive index of 1.4378. These values are valid for free space wavelengths of 1.55 μm. The radius of the cladding is chosen to be large enough so that the field of confined modes is zero at the outer boundaries. For a confined mode there is no energy flow in the radial direction, thus the wave must be evanescent in the radial direction in the cladding. This is clearly seen in the simulation of the fiber.

Light Propagation in Photonic Crystals

The study of photonic crystals involves electromagnetic modeling of periodic structures of alternating layers of materials with different refractive indexes. Depending on the type of structure and scale, a photonic band gap of forbidden wavelengths is obtained for the device. By destroying the periodic structure in a limited region of the crystal, a waveguide can be created. Such waveguides can be designed having very sharp bends without significant loss of radiation. This may enable an increase in integration density in photonic circuits by several orders of magnitude.

Stress-Optical Effects in a Silica-on-Silicon Waveguide

Planar photonic waveguides in silica (SiO_2) have great potential for use in wavelength routing applications. A major problem with this type of waveguide is birefringence resulting in splitting of the fundamental mode and pulse broadening. One source of birefringence is thermally induced stresses originating in the manufacturing process where the waveguide structure is deposited on a silicon (Si) wafer. After annealing at high temperature (approximately 1000°C), a mismatch in thermal expansivity between the silica and silicon layers results in thermally induced stresses in the structure at the operating temperature (typically room temperature, 20°C). The stresses affect the refractive index, and the material becomes birefringent. The design goal is to minimize birefringence effects by adapting materials and manufacturing processes. In order to examine the shape and effective index of the fundamental mode, it is critical to use prtotyping software that allows for full coupling of the heat transfer, structural, and optical analysis.

Design of a Photonics Micro-Prism

Another way to reduce radiation losses in photonics waveguide bends is to use a micro-prism. If a micro-prism is placed between two waveguides forming a sharp bend, light will be guided between the waveguides, through the prism. For a certain refractive index of the prism, the light propagating through the prism will couple to the respective mode under just the appropriate resonance angle. If the initial field distribution does not diffract while propagating through the prism, the coupling from the prism to the guide is the inverse to the transfer of the light from the guide to the prism. Therefore, the efficiency of the process is very high. The prism must be sufficiently long to allow almost all of the power to exit into the prism and vice versa. However, to avoid diffraction, the size of the prism should be kept as small as possible. The trade-off between coupling and diffraction effects is readily studied in a numerical model.

This article was submitted by COMSOL, Inc., 8 New England Executive Pk., Burlington, MA 01803. For more information e-mail info@comsol.com or call (781) 273-3322. The Los Angeles, CA office can be reached at (310) 689-7250. To find out more about FEMLAB software visit COMSOL online at www.comsol.com.

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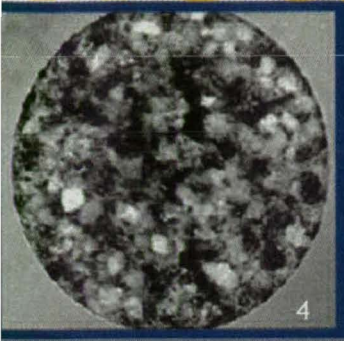

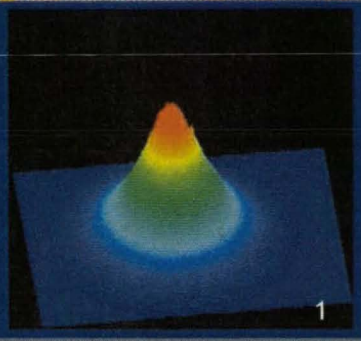

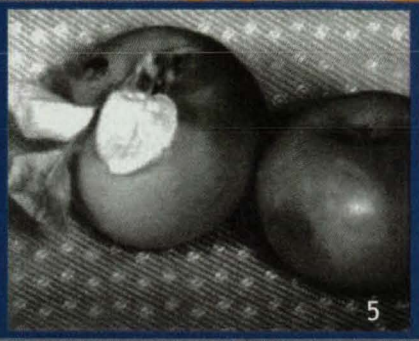

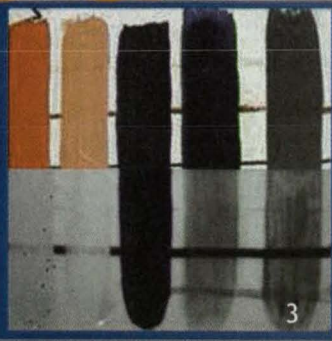

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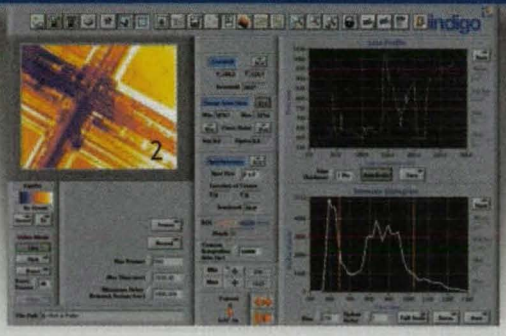

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Parallel Interconnect Modules:

The Reality for Telecom Routing & Switching

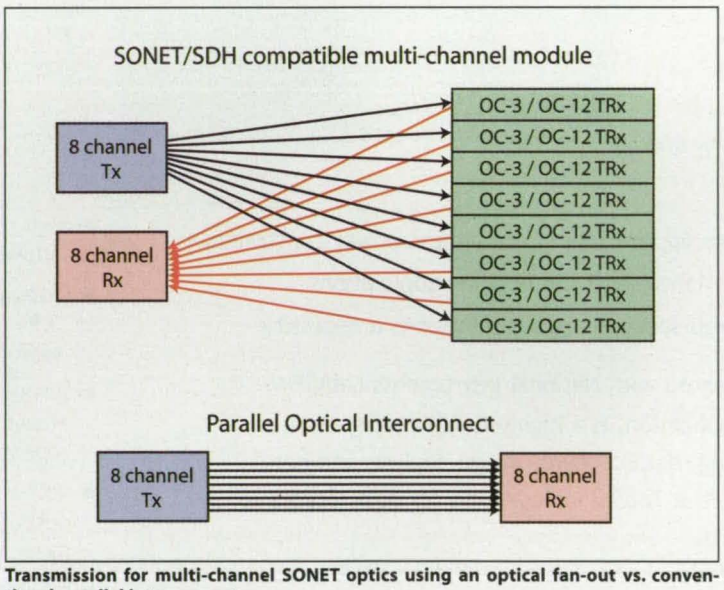
Telecom routers and switches have been pushing the limits of conventional interconnect technology. As routers and switches have become larger and more complex the connection from rack-to-rack or system-to-system has become a bottleneck. Copper interconnects have reached the limit in terms of speed and distance. This need led to the development of parallel optical interconnects. These interconnects transmit data in parallel over a fiber ribbon, enabling large throughputs that are now reaching up to 40 Gb/s with one link.

There are two competing technologies for the parallel interconnect market. The first uses conventional 1310 nm Fabry Perot edge emitting lasers. These lasers provide the benefit of proven reliability and the ability to transmit over Single Mode (SM) or Multi-mode (MM) fiber. The second technology is based on 850 nm Vertical Cavity Surface Emitting Lasers (VCSEL's). This technology is attractive because of lower cost; however, they can only transmit over MM fiber. Both technologies can transmit over MM fiber with distances of 300 meters or longer. Interconnects that use SM fiber can transmit distances of several kilometers.

Potential Advantages

Although the market for large switches and routers has slowed in the current economy, thus the demand for parallel optical interconnects has decreased, there is a new emerging application for this technology: SONET/SDH (Synchronous Optical Network/ Synchronous Digital Hierarchy) compatible multi-channel modules. SONET/SDH is still the predominant technology for optical transmission to the ports for telecom switching and routing equipment. System vendors are trying to put more and more optical transceivers in one board. Because of this, the size of single channel transceivers has been reduced. Packaging for SONET/SDH transceivers has gone from bulky 1x9 transceivers to Small Form Factor (SFF) transceivers. Currently system vendors are placing 16, 32, or more SFF transceivers on one line card. This takes up a large amount of board real estate. The next logical step is to place multiple transmitters and receivers in one package. This is where the technology used to develop parallel interconnects comes into play. Companies are now introducing multi-channel links that are compatible with existing SONET/SDH standards. By using multi-channel links vendors can cut their real estate for optics in half, or more. By offering compatibility with existing standards and leveraging the price advantage of multi-channel packaging, there is a significant advantage to using multi-channel modules to replace SFF parts.

In addition to the density savings, there are potential cost savings as well. Currently a SFF OC-12 IR TRx costs up to $200. With multi-channel optics, this cost can be cut in half to $100/channel. The cost reduction coupled with the 50% density improvement provides a tremendous advantage to the system designer.



Transmission for multi-channel SONET optics using an optical fan-out vs. conventional parallel interconnects.

Compatibility Requirements

The requirements for compatibility between a multi-channel optical link and existing SONET/SDH standards are different than those for conventional parallel interconnects. One fundamental difference is that for interconnects the transmission is from one transmitter to a receiver over a fiber ribbon. For multi-channel SONET optics, the transmission can be from many different single channel transmitters to a single multi-channel receiver (or vice-versa) by using an optical fan-out (see diagram).

The specifications are also different. In general, the Extinction Ratio (ER) must be larger for SONET links. In addition, the channel-to-channel crosstalk is much more important. The large majority of the SONET market is for lower data rate parts, either OC-3 (155 Mb/s) or OC-12 (622 Mb/s). These links must meet the Intermediate reach (IR) specifications. In order to meet the distance requirements of more than 15 km, the receiver sensitivity is critical. The OC-12 IR specification requires sensitivity of better than -28 dBm. In order to meet this requirement, the channel-to-channel crosstalk is critical.

Today there are many companies developing parallel interconnect modules. However, as the economy continues to struggle along, the ability to find new applications and new markets will be key to the survival of vendors of parallel interconnect technology.

This article was written by Chris Keller, general manger of the Technology Department, for Optobahn Corporation. The author may be contacted at ckeller@optobahn.com or (310) 768-2900. Visit Optobahn Corp. online at www.optobahn.com.

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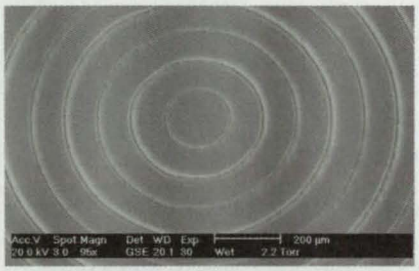
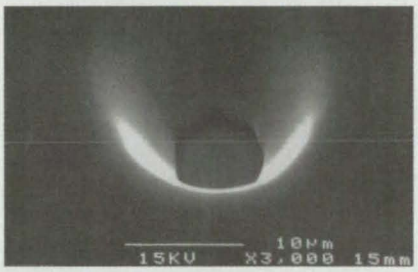
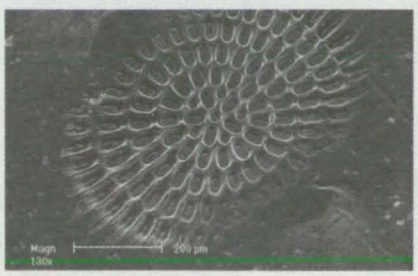


Fine line pattern etched in fused silica.



10µm via hole drilled in polymer. (Courtesy of IBM)



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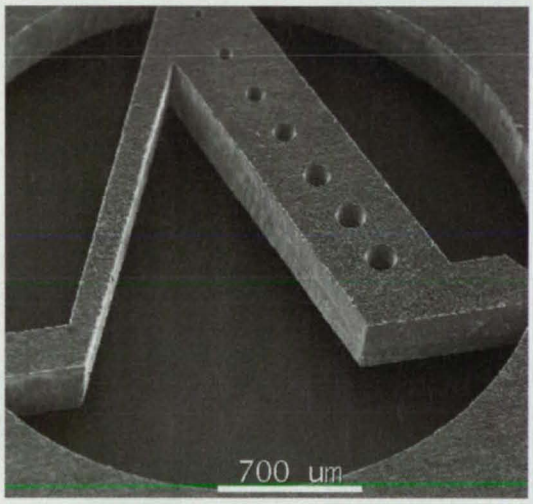

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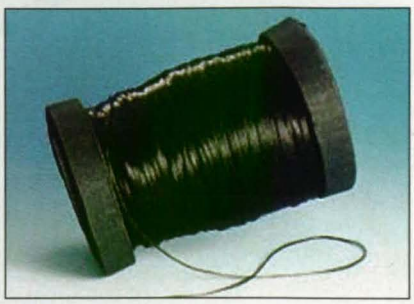
Ceramic Fibers for High Temperature Matrix Composites

Bayer AG

These low cost, low-density ceramic fibers are used to manufacture ceramic matrix composites for applications in aerospace, automotive, and power generation. Substantial operational cost reductions can be anticipated thanks to weight savings and thermal efficiencies.



When compared to superalloys and existing ceramic fibers, SIBORAMIC fibers exhibit superior high temperature mechanical properties. Benefits include resistance to oxidation and molten silicon at 1600°C, amorphous up to 1800°C, small coefficient of thermal expansion ($3 \cdot 10^{-6}$/K), and self-healing in oxygen atmosphere. They also have a low specific weight (1,8 g/cm³) and low electrical and thermal (0,4 W/mK at 1500°C) conductivity.

The fibers' economical production process does not require electron radiation curing or coating before incorporation into a matrix, which reduces composite manufacturing expenses.

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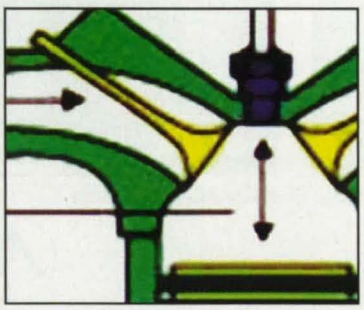
Single Detector Cylinder Recognition

Bosch

This cylinder recognition technology for internal combustion engines uses a single detector and simplified circuitry. Earlier technologies used two detectors, a comparator, a mono-stable multi-vibrator, and a significant quantity of electronic circuitry to identify the particular cylinder operating in the power stroke of the engine cycle.



The equipment from Bosch consists of an ignition controller for generating ignition signals; a signal distributor, which is connected to the ignition controller and to the ignition coils associated with two selected cylinders; one detector for generating a signal indicating spark generation in a cylinder; a processor for analyzing the signal generated by the detector; and a control circuit responsive to the processor for outputting a control signal indicating the particular cylinder, which is operating in the power stroke of the engine cycle.

According to Bosch, this simplified technology reduces production costs and has already been incorporated in internal combustion engines.

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Reflective Variants of Miniature Microscope Without Lenses

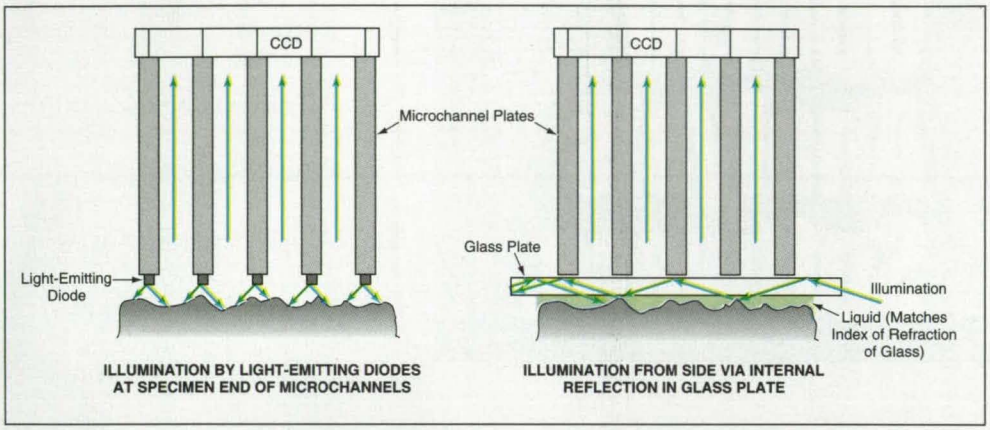
The specimen would be illuminated in reflection rather than in transmission.

NASA's Jet Propulsion Laboratory, Pasadena, California

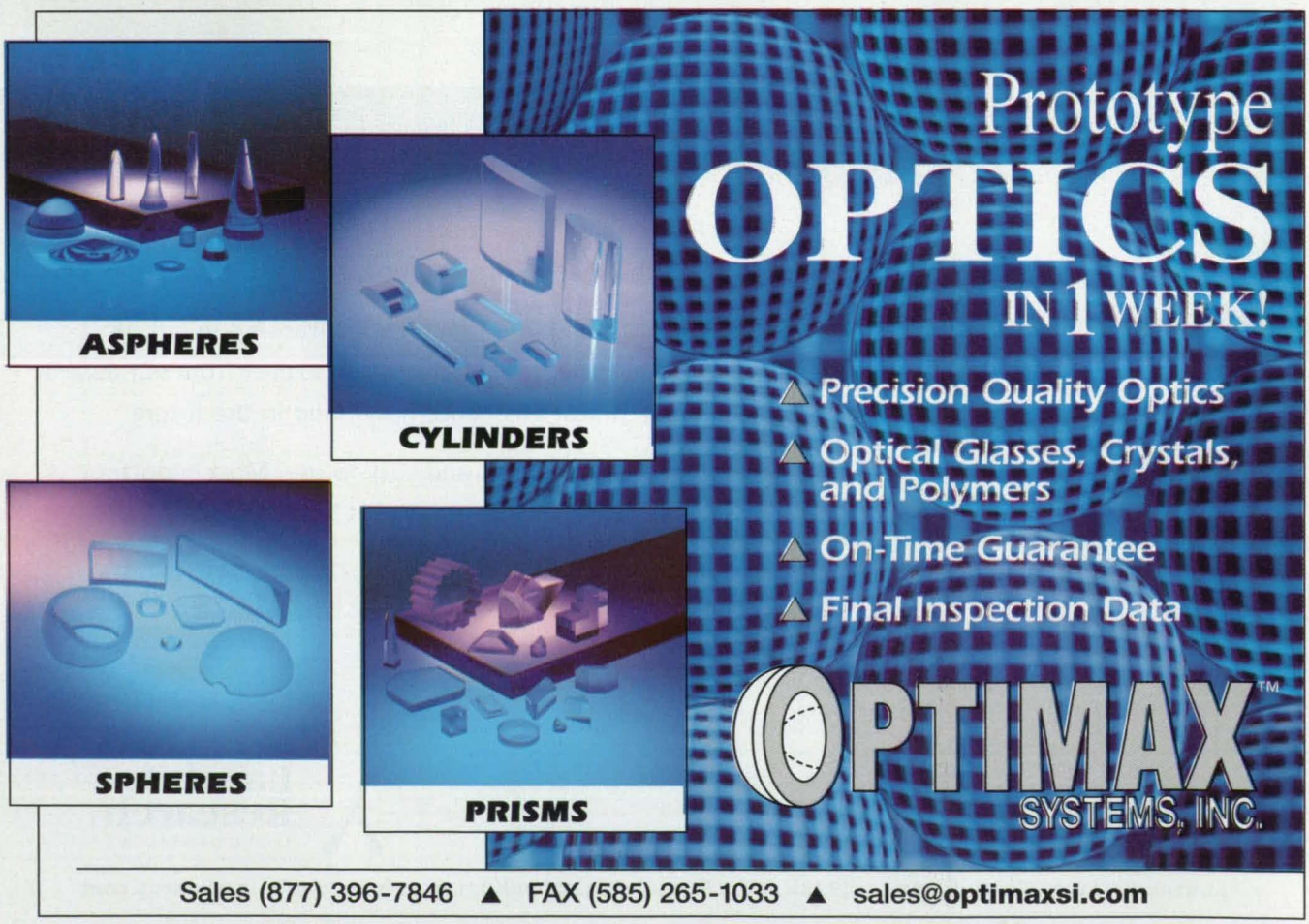
The figure schematically depicts two proposed alternative versions of an instrument that amounts, in effect, to a compact, lightweight optoelectronic microscope that contains no lenses and generates a magnified video image of a specimen. The instrument was described in "Miniature Microscope Without Lenses" (NPO-20218), Vol. 22, No. 8 (August 1998), page 43. In the design and construction of the instrument, the focusing optics of a conventional microscope were replaced by a combination of a microchannel filter and a charge-coupled-device (CCD) image detector. Elimination of focusing optics reduced the size and weight of the instrument and eliminated the need for the time-consuming focusing operation. At the time of the previous article, the instrument was only at the conceptual stage of development, but since that time, a prototype of the instrument has been built and demonstrated to function as intended.

The main differences between the previous version and the present proposed versions of the lensless microscope lie in the manner in which the specimen would be illuminated. The previous version was designed for a partly transparent but highly scattering specimen. The specimen was illuminated in a transmission mode with highly collimated light that was aimed through the specimen parallel to the axes of the microchannels.

According to the present proposal, the specimen would be illuminated in ei-



This **Miniature Microscope**, like its predecessor described in the cited prior article, would not contain any lenses or other focusing optics. Focusing would not be necessary because the microchannels would effect a one-to-one mapping from locations on the specimen to pixel locations on the CCD.



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ther of two reflection modes. In one case, the illumination would be provided by microscopic light-emitting diodes mounted on the walls between the microchannels, facing the specimen. In the other case, the specimen would be covered by a glass plate. Illumination would be brought in from the side by total internal reflection in the glass plate. A fluid with an index of refraction equal to that of the glass would be placed between the specimen and the glass plate to couple the illumination onto the specimen. There would be a thin airgap between the glass plate and the microchannel plate. Some of the light scattered and reflected by the specimen would travel along the microchannels to the CCD, as in the other versions of this instrument.

This work was done by Yu Wang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
NPO-20610

Spectral Region for Laser Isotope Measurements of Gases

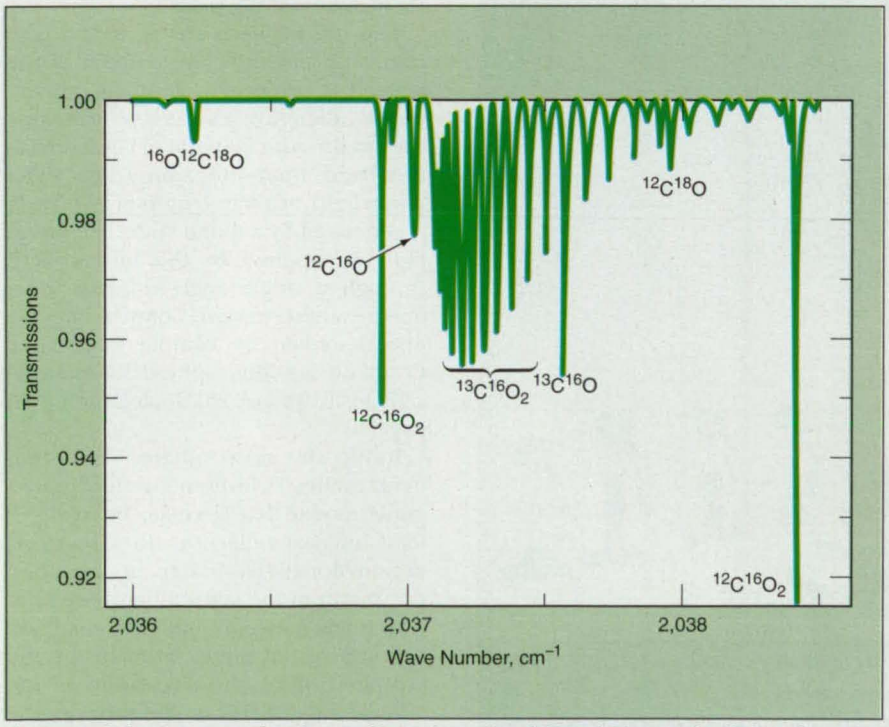
Tunable-laser absorption measurements yield temperature and concentrations of six isotopic species.

NASA's Jet Propulsion Laboratory, Pasadena, California

A mid-infrared wave-number range has been identified as being useful for laser measurements of CO and CO_2 gases that contain various combinations of isotopes of C and O. The isotopic species are $^{12}C^{16}O$ (common CO), $^{13}C^{16}O$, $^{12}C^{18}O$, $^{16}O^{12}C^{18}O$, $^{12}C^{16}O_2$ (common CO_2), and $^{13}C^{16}O_2$.

More specifically, the wave-number range from about 2,036.2 to 2,038.4 cm^{-1} (wavelength range from about 4.9111 to about 4.9058 μm) contains two absorption spectral lines for $^{12}C^{16}O_2$, a group of lines for $^{13}C^{16}O_2$, and one line for each of the other isotopic species (see figure). The range is narrow enough that it can be spanned by a typical tunable laser.

From measurements of the absorption of laser light in this wavelength range, one can determine simultaneously the temperature of a gas mixture and the concentration of each of the six



The **Transmission Spectrum** of a mixture of isotopic species of CO and CO_2 contains distinct absorption lines for each of the species in narrow wave-number range centered at about 2,037 cm^{-1}. The $^{13}C^{16}O_2$ Q-branch lines would provide an independent determination of temperature. The spectral simulation shown is typical for Mars atmospheric conditions.

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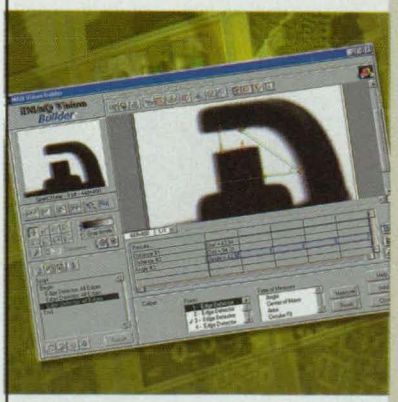

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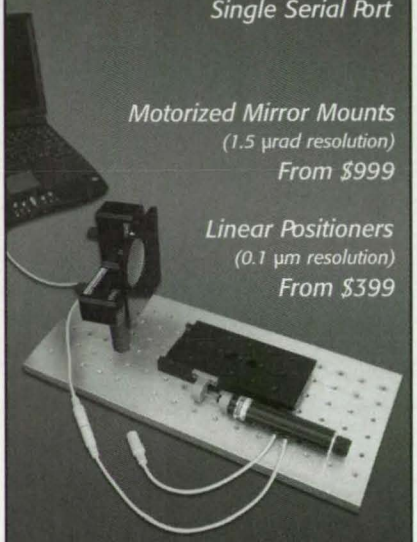

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isotopic species. Potential applications for instruments based on this measurement principle include Earth and planetary gas spectrometers; analysis of exhaled, isotope-tagged CO and CO_2 for medical diagnosis; analysis of isotope-tagged CO and CO_2 for research on the operation of automotive engines and the resulting pollution; and other applications in industries that involve the sensing and/or measurement of gases.

This work was done by Christopher Webster of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
NPO-21163

Fiber-Coupled Microsphere Laser at Wavelength of 1.55 µm

Coherent radiation can be generated or amplified by an extremely compact device.

NASA's Jet Propulsion Laboratory, Pasadena, California

The figure depicts the laboratory setup of an optical-fiber-coupled microsphere laser with an output in the 1.55-µm wavelength band used in some communication systems. This laser offers the obvious advantages of compactness and simplicity. In addition, as consequences of the high resonance quality factor (Q) and smallness of the microsphere, it also offers the non-obvious advantages of a high degree of spectral purity and a low threshold power level. This laser could be useful as a source of highly coherent infrared light or, if operated in a sub-threshold regime, as a low-noise front-end amplifier in optical communication. Alternatively, with the addition of active mode locking, this laser could be the core of an ultra-compact optoelectronic oscillator that would generate a light signal modulated by a microwave signal according to the principle described in "Closed-Loop Microsphere Laser for Optoelectronic Oscillator" (NPO-20597), *NASA Tech Briefs*, Vol. 25, No. 9 (September 2001), page 14a.

The microsphere serves as both the resonator and the gain medium of the laser. It is made of a standard erbium-doped aluminosilicate glass ordinarily used as the core material of communication-band fiber-optic amplifiers. The pump light, at a wavelength of 977.6 nm, is generated by a diode laser. The pump light is supplied to the microsphere through a single angle-polished fiber-optic evanescent-wave coupler like the one described in "Simple Fiber-Optic Coupling for Microsphere Resonators" (NPO-20619), Vol. 25, No. 5 (May 2001), page 70.

Inside the microsphere, the pump light excites "whispering-gallery" waveguide modes that circulate by virtue of total internal reflection. In a standard erbium-doped-fiber laser or amplifier, the length of the active fiber must be at least a few meters to obtain enough absorption of the pump light. In the microsphere laser, the circulation of the "whispering-gallery" modes provides the necessary path length for absorption, thus making it possible to reduce the laser volume drastically. The 1.55-µm

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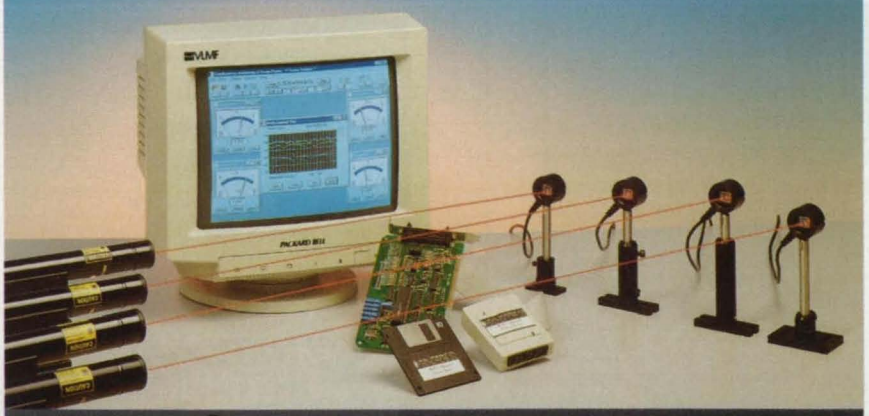

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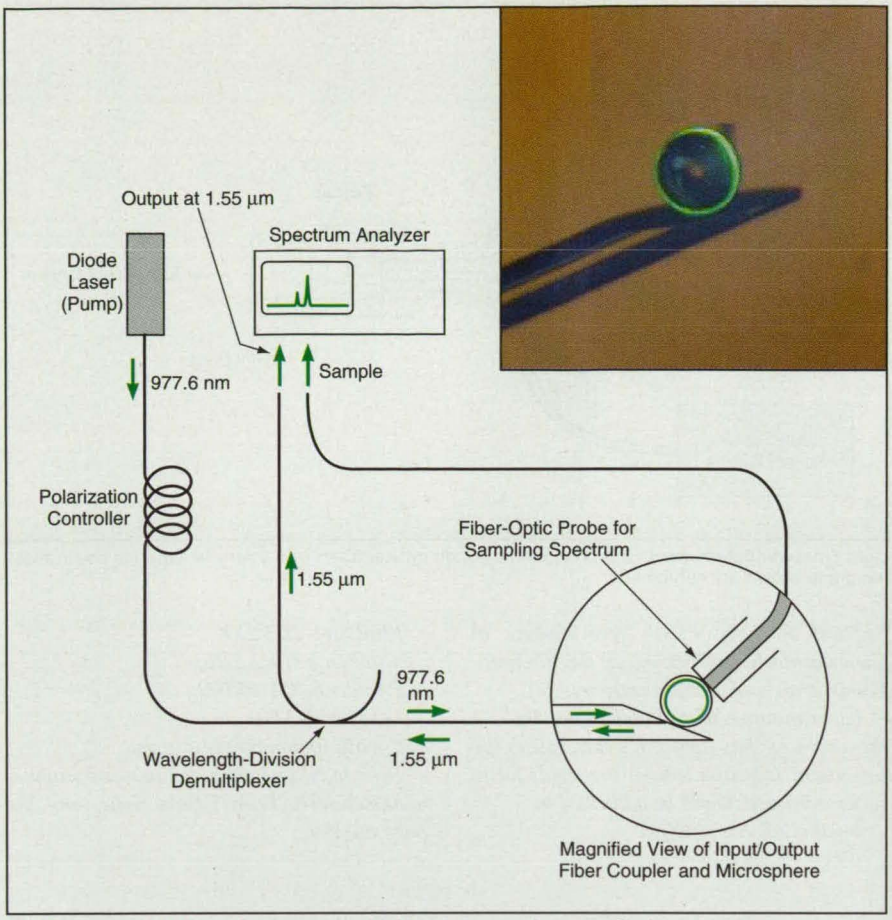

This **Fiber-Coupled Microsphere Laser** is a highly miniaturized source of coherent radiation at a wavelength of 1.55 μm. In the photograph, the lasing region is rendered visible by up-conversion-pumped fluorescence at wavelengths of 525 and 545 nm.

laser radiation is coupled back into the optical fiber and selected for output by a wavelength-division demultiplexer.

This work was done by Vladimir Iltchenko, Steve Yao, and Lutfollah Maleki of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to NPO-20918, volume and number of this NASA Tech Briefs *issue, and the page number.*

Multiple-Pump Lasers

Fiber-optic coupling is exploited to increase reliability without excessive complexity.

NASA's Jet Propulsion Laboratory, Pasadena, California

A conceptually simple, effective scheme for reliable, high-power pumping of neodymium:yttrium aluminum garnet (Nd:YAG) lasers (and perhaps also other solid-state lasers) has been devised. Heretofore, it has been common practice to pump a Nd:YAG crystal by use of a single diode laser. However, diode lasers are not reliable enough to support long-life, high-power operation. If multiple diode lasers could be used to pump a single Nd:YAG crystal, then laser operation would be less degraded by the deterioration or failure of a single diode laser.

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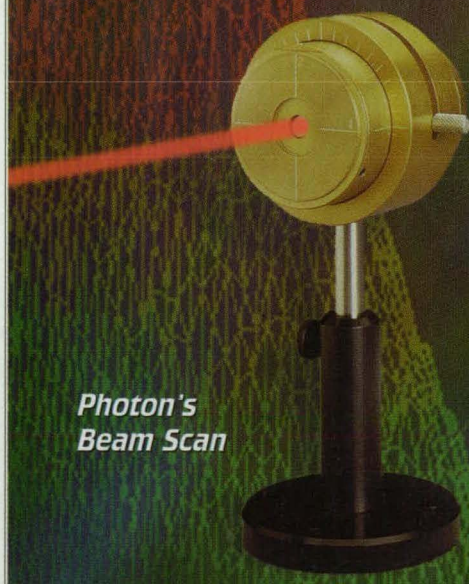

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One alternative scheme for coupling light from multiple laser-diode pumps into a single Nd:YAG crystal would involve the integration of multiple laser diodes, along with relatively complicated optics, onto a single chip. In such an arrangement, it would not be possible to change the number of pumps. Moreover, the pumps would not be isolated from each other, so that failure of one could adversely affect the operation of the others.

In contrast, the present scheme affords optical isolation of the pump lasers from each other, is amenable to addition or removal of pump lasers, and involves relatively simple optics. The output ends of the fibers of multiple independent fiber-coupled laser diodes are bundled together in a ferrule (see figure). A gradient-index-of-refraction (GRIN) lens in the ferrule combines the multiple pump beams into a single beam aimed into the Nd:YAG crystal. The failure of one laser diode does not affect the operation of the others, and the light from the others continues to pump the Nd:YAG crystal.

This work was done by Serge Dubovitsky, Jerry Mulder, and Duncan Liu of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Electronic Components and Systems category.*

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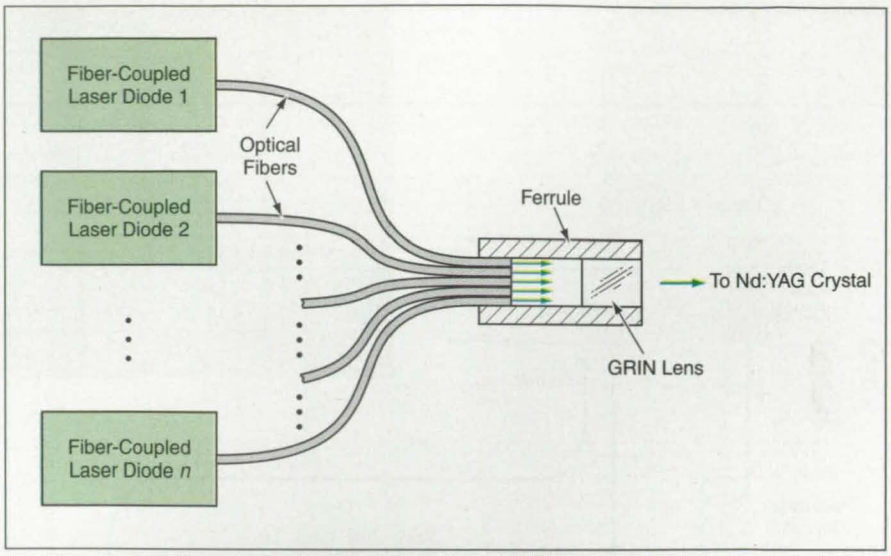

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Product Guide: Tunable Lasers

CONTINUOUS WAVE TUNABLE LASERS

Wavelength Range (nm)	Tuning Range	Tuning Speed	Line Width	Output Power (W)	Pumping Method	Model	Company
370 - 1100	—	—	<500 kHz	>2, peak	DPSS or Ar ion	899-21 or -29	Coherent
400 - 940	—	—	40 GHz	>3, peak	DPSS or Ar ion	599	Coherent
650 - 678	70 GHz	—	<300 kHz	0.002 - 0.006	Diode laser	6009 Vortex	New Focus
675 - 1100	—	—	<1 GHz	3.5	Argon ion or CW green SS laser	3900S	Spectra-Physics
690 - 1100	—	—	<30 GHz	>3, peak	DPSS or Ar ion	890/899-LC	Coherent
700 - 1000	—	—	<100 kHz	>1.5, peak	DPSS or Ar ion	MBR-110	Coherent
795 - 853	60 GHz	—	<300 kHz	0.002 - 0.007	Diode laser	6017 Vortex	New Focus
960 - 995	960 - 995	12 nm/sec	<300 kHz	0.008 typ., max.	Diode laser	6320 Velocity	New Focus
1064 - 1600	—	—	<2 nm	up to 10	Laser diode	BWC-FL-1064	B&W Tek
1064 - 1600	—	—	<2 nm	up to 20	Laser diode	BWC-FL-1115	B&W Tek
1064 - 1600	—	—	<2 nm	up to 5	Laser diode	BWC-FL-1290	B&W Tek
1280 - 1340	1280 - 1340	15 nm/sec	<300 kHz	0.008 typ., max.	Diode laser	6324 Velocity	New Focus
1290 - 1340	—	1s typ.	150 kHz	up to 0.002	Laser diode	Tunics-Plus O	NetTest
1360 - 1430	—	1s typ.	150 kHz	up to 0.002	Laser diode	Tunics-Plus E	NetTest
1390 - 1540	—	1s typ.	150 kHz	up to 0.006	Laser diode	Tunics-Plus S/WB	NetTest
1415 - 1480	1415 - 1480	20 nm/sec	<300 kHz	0.008 typ., max.	Diode laser	6327 Velocity	New Focus
1430 - 1530	—	1s typ.	150 kHz	up to 0.002	Laser diode	Tunics-Purity S	NetTest
1470 - 1520	50 GHz	—	<300 kHz	0.006 - 0.010	Diode laser	6027 Vortex	New Focus
1490 - 1640	—	1s typ.	150 kHz	up to 0.006	Laser diode	Tunics-Plus CL/WB	NetTest
1500 - 1600	—	1s typ.	150 kHz	up to 0.010	Laser diode	Tunics-Plus 10	NetTest
1520 - 1570	30 GHz	—	<300 kHz	0.005 - 0.007	Diode laser	6029 Vortex	New Focus
1520 - 1620	1520 - 1620	1 - 100 nm/sec	10 MHz typ.	0.004	Diode laser	TLB-6528-H	New Focus
1521 - 1621	16, 32 nm	10 ms	20 MHz typ.	0.010, 0.020	MEMS VCSEL	ML-20	Nortel Networks
1525 - 1565	40 nm	10 ms	10 MHz	0.010	SG-DBR/SOA	3015	Agility
1525 - 1565	40 nm	10 ms	30 MHz	0.002	SG-DBR/EAM	4245	Agility
1525 - 1625	—	1s typ.	150 kHz	up to 0.002	Laser diode	Tunics-Purity CL	NetTest
1528 - 1605	8 channels	—	10 MHz typ.	0.020	InGaAsP DFB laser chip	LCW508ET	Nortel Networks
1570 - 1640	30 GHz	—	<300 kHz	0.005 - 0.015	Diode laser	6031 Vortex	New Focus

PULSED TUNABLE LASERS

Wavelength Range (nm)	Linewidth (nm or MHz)	Energy	Rep Rate (Hz)	Pulse Width (ns)	Pumping Method	Model	Company
205 - 1000	<1 cm^{-1}	—	10-10 kHz	20 - 50 ns	Green Nd:YLF	Proteus	Quantronix
205 - 2550	<6.5 cm^{-1}	>100 mJ, peak	10 - 50	3-7 ns	Nd:YAG	Panther OPO	Continuum
210 - 400	Variable	1 - 4 mJ	10	5 ns	Doubling or mixing OPO	VIBRANT UV module	Opotek
220 - 1800	<0.075 cm^{-1}	up to 75 mJ	10, 20	~ 5 ns	Nd:YAG	MOPO-HF	Spectra-Physics
220 - 2300	Depends on wavelength	up to 80 mJ	10, 20, 30	~ 5 ns	Nd:YAG	MOPO-PO	Spectra-Physics
225 - 1750	≤0.075 cm^{-1}	40, 50 mJ, peak	10, 20	3-6 ns	Nd:YAG	Sunlite EX OPO	Continuum
300 - 500	Variable	> 5 mJ, max.	10, 20	5 ns	266 nm Nd:YAG	VIBRANT 266OPO	Opotek
300 - 10000	Depends on pulse width	75 µJ @ 1300 nm	1, 5 kHz	50 fs, 90 fs, 130 fs, 2 ps	Ti:sapphire amplifier	OPA-800C	Spectra-Physics
410 - 2400	Variable	>3, >5 mJ	20	5 ns	355 or 532 nm Nd:YAG	Opolette	Opotek
410 - 2400	Variable	35, 70 mJ	10, 20	5 ns	355 nm Nd:YAG	VIBRANT 355OPO	Opotek
410 - 2630	50 - 300 cm^{-1}	10, 35 mJ, peak	10, 20	3-5 ns	Nd:YAG	Surelite OPO	Continuum
480 - 2400	—	3 - 4 uJ, peak	0 - 250 kHz	fs	Ti:sapphire	RegA-OPA	Coherent

Wavelength Range (nm)	Linewidth (nm or MHz)	Energy	Rep Rate (Hz)	Pulse Width (ns)	Pumping Method	Model	Company
525 - 665	—	~2 nJ	76 MHz, std.	fs or ps	Ti:sapphire	Mira-OPO-SHG	Coherent
680 - 2400	Variable	40, 100 mJ	10, 20	5 ns	532 nm Nd:YAG	VIBRANT 532OPO	Opotek
690 - 1080	Depends on pulse width	25 nJ @ 800 nm	80 MHz	35 fs - 80 ps	CW green SS laser	Tsunami	Spectra-Physics
700 - 1000	—	>17 nJ	76 MHz, std.	fs or ps	Verdi DPSS or Ar ion	Mira	Coherent
720 - 930	—	>11 nJ	90 MHz	<140 fs	Verdi DPSS	Chameleon	Coherent
750 - 850	~12 nm @ 800 nm	9 nJ @ 800 nm	80 MHz	<100 fs	Single diode laser module	Mai Tai	Spectra-Physics
750 - 900	Depends on pulse width	up to 2.25 mJ	1, 5, 50 kHz	50 fs, 90 fs, 130 fs, 2 ps, 80 ps	Nd:YLF	Spitfire	Spectra-Physics
780 - 920	~12 nm @ 850 nm	9 nJ @ 800 nm	80 MHz	<100 fs	Single diode laser module	Mai Tai	Spectra-Physics
1050 - 3000	—	~3 nJ	76 MHz, std.	fs or ps	Ti:sapphire	Mira-OPO-IR	Coherent
1100 - 2300	~20 nm @ 1300 nm	2 nJ @ 1300 nm, 1500 nm	80 MHz	<130 fs	Ti:sapphire oscillator	Opal	Spectra-Physics
1527 - 1563	1.0 nm	—	—	—	InGaAsP DFB laser chip	MT25 Series	Nortel Networks
1528 - 1563	0.6 nm	—	—	—	InGaAsP DFB laser chip	LC25 Series	Nortel Networks
2700 - 3500	3-4 cm^{-1}	>5 mJ	10	4 ns	Nd:YAG	IR-OPO	Opotek

Company	URL
Agility Communications, Inc.	www.agility.com
B&W Tek Inc.	www.bwtek.com
Coherent, Inc.	www.coherentinc.com
Continuum	www.continuumlasers.com
NetTest Inc.	www.nettest.com
New Focus	www.newfocus.com
Nortel Networks - Optical Components	www.nortelnetworks.com/opticalcomponents
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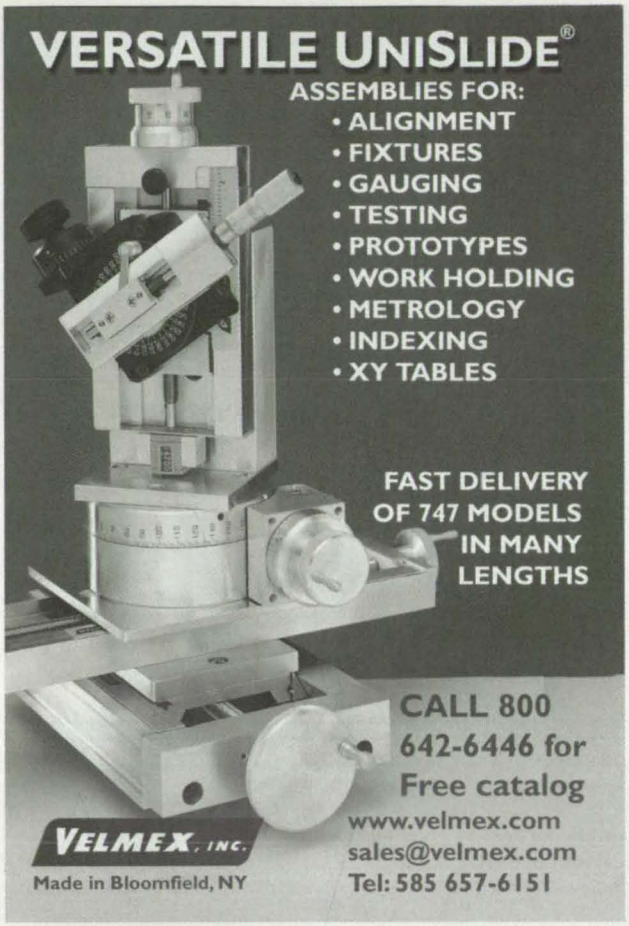

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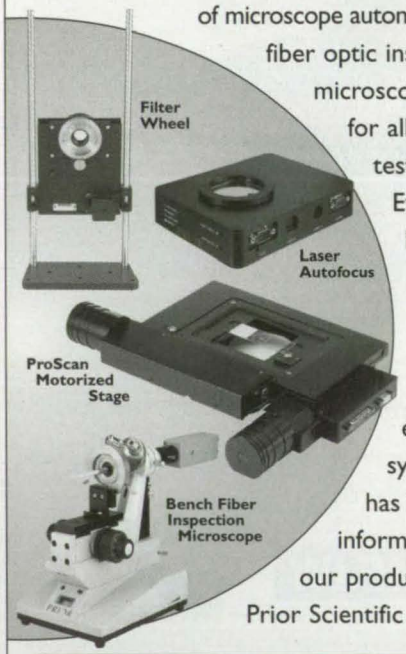

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New Products

Product of the Month

RF Automated Accelerated Characterization Test System

The RF single-rack 4- and 8-channel version of Maxwell Technologies' (San Diego, CA) Automated Accelerated Reliability Test Systems (AARTS) is offered in two frequency bands — 600 MHz to 3GHz, and 900MHz to 10GHz. These systems perform accelerated-aging performance characterization tests on discrete transistors, monolithic microwave integrated circuits (MMICs), hybrid microwave integrated circuits (HMICs), and RF/microwave module assemblies. The system consists of hardware and software used to initiate, supervise, and record temperature, electrical, and RF performance parameters automatically throughout the test duration.

For Free Info Visit www.nasatech.com/maxwell

F-Theta Scan Lenses

F-Theta Ronar scan lenses from LINOS Photonics (Milford, MA) have a compact design for small, fast scan heads with apertures from 5 to 8mm. Featuring a screw thread of M39x1 and outer diameter of 47mm, the series consists of lenses with a focal length of 160mm (1064 and 532nm wavelengths) and 63mm (1064, 532, and 830nm wavelengths). Long focal range F-Theta lenses offering 635mm focal length for a wavelength of 532nm, and an image field of 390 x390mm², are also available. Aberration-free imaging is achieved up to a beam diameter of 20mm, resulting in a spot size of 32µm with an edge intensity of $1/e^2$.

For Free Info Visit www.nasatech.com/linos

Femtosecond Laser System

The Titan-10K Ultrafast micromachining system from Quantronix (East Setauket, NY) combines a 100 µJ, 10 kHz, 100 fs Laser system with an industrially proven beam delivery system. The combination of sub 100 fs pulses, high pulse energy and 10 kHz repetition rate delivers Peak Powers over 50 GW and 10X faster processing speeds. This Ultrafast Micromachining System consists of a Diode-pumped Solid-State Ti:Sapphire Oscillator, Solid-State Pump Laser, Ti:Sapphire Regenerative Amplifier, High precision/accuracy fixed beam delivery system, XY-Positioning Table, and a Windows™ based Fully Integrated Laser Machining Software.

For Free Info Visit www.nasatech.com/quantronix

Ultra-high Damage Threshold 1064 nm Optics

A new range of components from Alpine Research Optics (Boulder, CO) delivers ultra-high damage threshold and maximum pulse count lifetime when used with high peak power, q-switched, 1064 nm Nd:YAG and Nd:YVO_4 lasers. These high performance coatings withstand up to 40 J/cm² for high reflection (mirror) designs and up to 20 J/cm² for antireflection designs. The standard component line includes mirrors, partial reflectors, windows for 0° and 45° operation, and a range of spherical and cylindrical lenses. Round parts available in diameters up to 75 mm. Lenses offer radius of curvature between 0.05 and 10 meters.

For Free Info Visit www.nasatech.com/alpine

Optical Signal Sensor

Oluma's (Carlsbad, CA) Optical Signal Sensor (OSS) combines the function of a tap coupler and photodiode in one small, low-cost, high-performance package. The OSS monitors power levels between -40 dBm and +25 dBm in the S, C, and L bands. Several configurations are available in channel counts from 1 to 8 eliminating discrete components and excessive fusion splice points. Oluma's proprietary power monitoring technology and patented fiber waveguide assembly processes are the basis of these components that are now shipping. Production quantities and evaluation samples are available.

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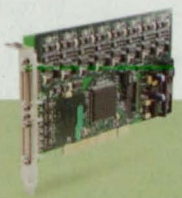

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GUI Software for Managing Router Configuration Files

Cisco IOS Manager (CIOSMAN) is a computer program that generates a graphical user interface for managing configuration files for an Internet-Protocol router. [In this context, "IOS" signifies the Cisco Internetworking Operating System and "router" signifies a system of computer-network switching hardware and software.] Heretofore, the management of configuration files has been difficult, time-consuming, and error-prone because (1) the files tend to be large and complex, especially when they contain large access control lists (ACLs); and (2) it has been necessary to update the files by manual text editing. CIOSMAN includes routines for analyzing master configuration files or a router configuration dump (to show a running configuration) and for manipulating of specific interfaces and ACLs via point-and-click selection. A multiform capability enables the user to navigate among forms without backing out of a previously chosen form. Changes in interface or ACL information are validated before they are applied to the affected database. There is an option for compiling and updating a file: this option provides all the commands needed to apply a change to an ACL on line via either an integrated or a separate Telnet application program.

This program was written by Wayne Edward Morse of United Space Alliance for **Kennedy Space Center**. *For further information, please contact:*

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KSC-12304

Software for Managing a Health and Environmental Database

Health and Environmental Resource System (HERS) is a relational-database computer program with a graphical user interface that assists members of an environmental health organization in the collection, analysis, and reporting of data pertaining to industrial hygiene, radiation health, environmental sanitation, control of pollution, management of construction, management of hazardous materials, and administration. Prior to the development of HERS, most of the data were stored, variously, in paper files or in non-relational computer files accessible by only one user. Consequently, there was no easy way to perform comprehensive assessments of risk, and reporting was jeopardized by inconsistency and unavailability of data. HERS is designed for a multiuser environment and provides for interactive management of data as well as robust tracking and scheduling of tasks. Web-based application programs to be linked with HERS are being developed to enable the exchange of data with customers and with employees in the field. Also under development is a capability for importing data from a geographical information system so that HERS data can be linked to map locations: All the data about a location shown on a map will be accessible by clicking on a mouse.

This program was written by Pamela Tucker and additional applications to enhance the program were also written by Chris Erickson, Kevin Garbin, and Gary Palmer, Jr., of Comprehensive Health Services for **Kennedy Space Center**. *For further information, please contact:*

Pamela Tucker or
Gary Palmer
8810 Astronaut Blvd.
Suite 145
Cape Canaveral, FL 32920
Tel. No.: (321) 867-9014
E-mail: pamela.tucker-1@ksc.nasa.gov or gary.palmer-3@ksc.nasa.gov
KSC-12248

Software Accelerates and Standardizes Procurement by NASA

Virtual Procurement Office (VPO) is a Web-based application program designed for use by procurement professionals throughout NASA. Prior to the development of VPO, each of the 700+ NASA procurement professionals had to spend much time searching numerous locations on-line and off-line for the various software tools and other resources necessary to complete each procurement task. VPO accelerates and standardizes the work of these professionals by giving them accurate and efficient means for gaining access to all relevant on-line resources that support the procurement process. The resources include (1) rules (e.g., Federal Acquisition Regulations); (2) samples (e.g., prior procurement documents that might be useful as guides); and (3) "build tools" — application software, forms, and document templates that should be used to complete procurement tasks. In order to provide a familiar interface, VPO was structured following the matrix format of NASA Form 1098, Checklist for Contract Award File Content. Each row on the matrix represents a possible step in the contracting process, e.g., market research or acquisition plan. For each row on the matrix, VPO provides a column with the capability to include "rules," "samples," "build tool," and "status."

This program was written by Jim Bradford, Dwight Clark, Steve Rowell, David Hieber, John Sudderth, and Laura Allen of **Marshall Space Flight Center**; *Gene Moses, Joanne Comstock, Deborah Glass, and Larry Reeve of Ames Research Center; Robert Greco of Dryden Flight Research Center; Wanda Behnke and Mary Ann Bishop of Goddard Space Flight Center; George Huff, Leigh Allen, and Kelly Mepham of Johnson Space Center; Sandy Gates and Donna Rafferty of Kennedy Space Center; Sandra Ray, Linda Urquhart, and Mary Deuell of Langley Research Center; Bruce Shuman of Glenn Research Center; Gay Irby and Jane Johnson of Stennis Space Center; and Michael Lalla of WSTF. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

For further information, contact Caroline Wang, MSFC Software Release Authority, at (256) 544-3887 or caroline.k.wang@msfc.nasa.gov. Refer to MFS-31699.

Software for Scientific Exploration by Multiple Rovers

Multi-Rover Integrated Science Understanding System (MISUS) is a computer program designed to coordinate the activities of multiple small, instrumented robotic vehicles (rovers) engaged in autonomous scientific exploration of the surface of Mars. MISUS includes a component that utilizes machine-learning clustering methods to analyze scientific data (principally, image and spectral features of rocks) and, on the basis of analyses, to select new scientific activities. MISUS also includes a distributed-planning-and-sched-

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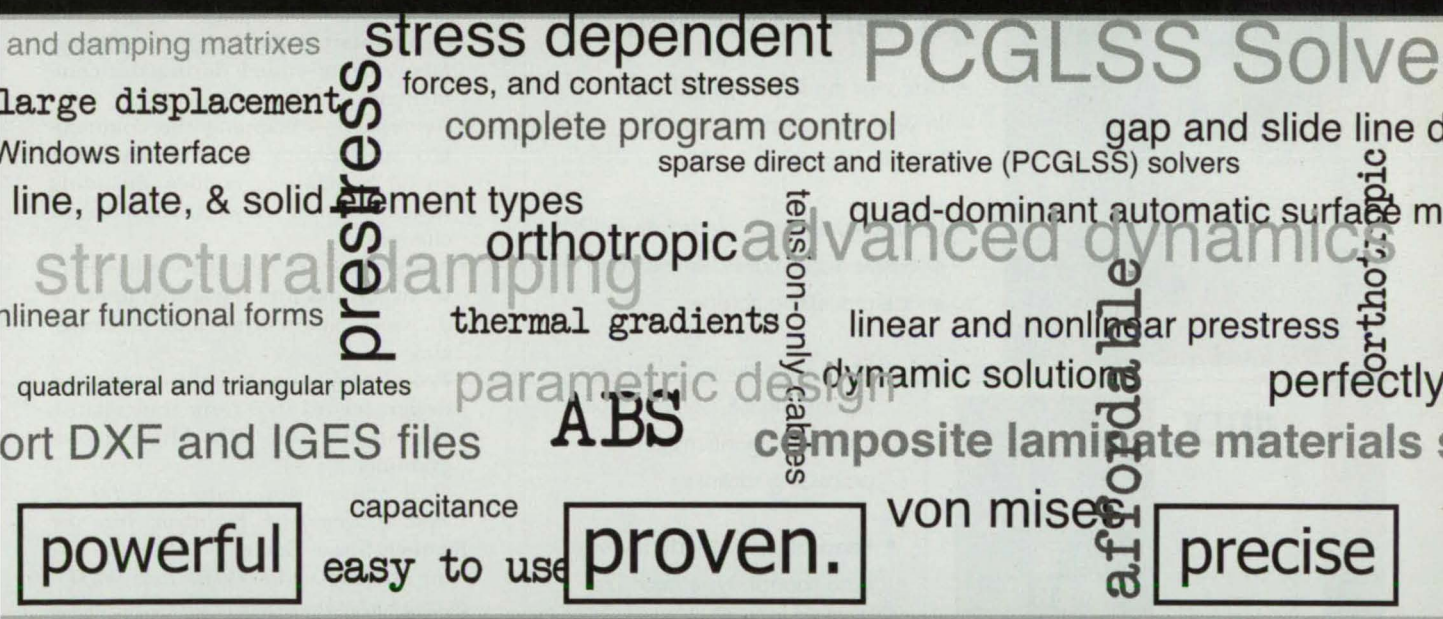

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uling component that determines the rover activities needed to achieve scientific goals, partly on the basis of initial rover conditions and an input set of goals. Plans are updated on the basis of the results of the scientific analyses and current information on the execution of commands and utilization of resources. Planning is distributed among the individual rovers, each rover being responsible for planning its own activities. A central planning system is responsible for dividing up the goals among the individual rovers in a fashion that minimizes the total time of traversal of all rovers. The software as described thus far is also integrated with a simulation program that simulates multiple-rover scientific operations on Mars-like terrain.

This program was written by Tara Estlin, Alexander Gray, Darren Mutz, Ashley Davies, Eric Mjolsness, Gregg Rabideau, John Lou, Rebecca Castaño, Steve Chien, and Tobias Mann of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Software category.*

This software is available for commercial licensing. Please contact Don Hart of the California Institute of Technology at (818) 393-3425. Refer to NPO-30201.

Software for Capturing Software-Design Rationale

Better Elicitation and Communication of Arguments Underlying Software Engineering (BECAUSE) is a computer program that records and codifies the rationale that underlies decisions made in the course of developing software. To minimize the additional sensory, cognitive, and motor demands upon the computer programmer and the time needed for the rationale-capture task, BECAUSE elicits spoken commentary, from the programmer, in regard to the specific software design or source code on which the programmer is currently working. Therefore, a microphone and speech-digitizing circuitry are used and BECAUSE incorporates speech-recognition software that processes digitized speech signals. BECAUSE also incorporates subprograms that perform the following functions:

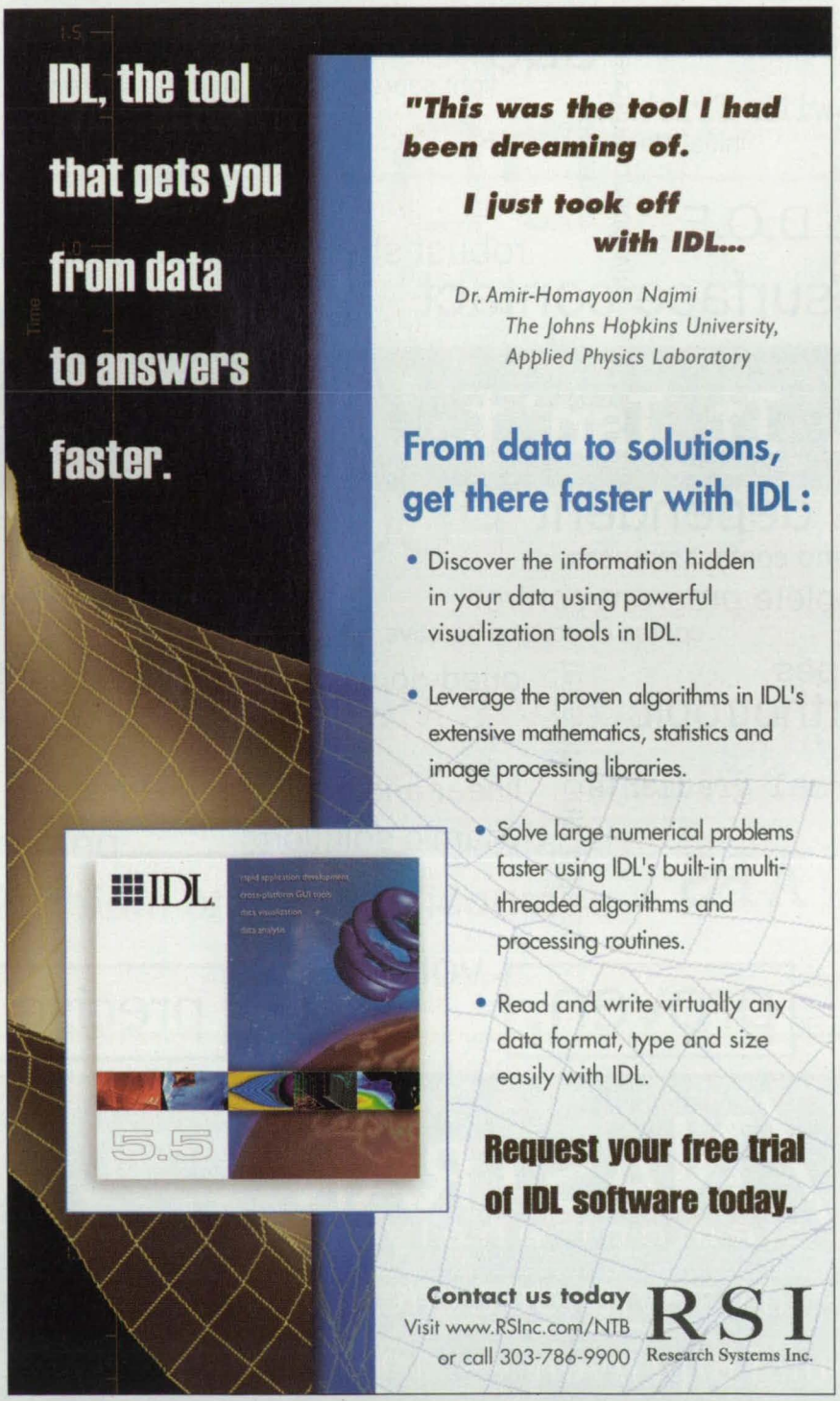
- *Elicitation* — asking questions of the programmer to stimulate commentary;
- *Correlation* — mapping the captured commentary to the design or code segments being edited during the commentary;
- *Abstraction* — mapping the commentary to explicitly or implicitly referenced higher-level entities, including issues, software objects, and design changes;
- *Navigation* — placing the commentary via hyperlinks within a stored network of issues, alternatives, and decisions; and
- *Presentation* — rendering the captured design record in a form understandable to the same or a different programmer.

This program was written by Sidney C. Bailin of Knowledge Evolution, Inc., for **Kennedy Space Center**.

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Sidney Bailin
Knowledge Evolution, Inc.
1050 17th St., NW
Suite 520
Washington, DC 20036
Tel. No.: (202) 467-9588 Ext. 10
E-mail: sbailin@kevol.com

Refer to KSC-12339, volume and number of this NASA Tech Briefs *issue, and the page number.*



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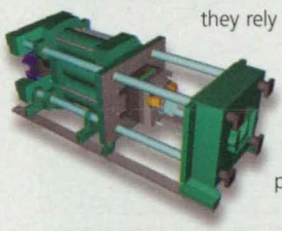

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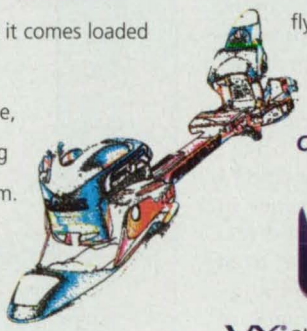

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Fabricating Better PSSA-PVDF-Based MEAs for Fuel Cells

Changes in the fabrication process enhance electrochemical performance.

NASA's Jet Propulsion Laboratory, Pasadena, California

Some changes have been made in the fabrication of PSSA/PVDF-based membrane/electrode assemblies for direct methanol fuel cells. The effect of the changes is to improve the electrochemical performances of the cells.

Some rather detailed background information is prerequisite to a meaningful description of the changes. Each fuel cell contains a membrane/electrode assembly (MEA), which is a composite of a solid-electrolyte membrane sandwiched between catalyzed electrode layers. PSSA/PVDF is a composite material that has been recently found to be useful for making solid electrolyte membranes, as reported in "PSSA/PVDF Polymer Electrolyte Membranes for CH_3OH Fuel Cells" (NPO-20378), *NASA Tech Briefs*, Vol. 23, No. 6 (June 1999), page 54. To recapitulate: a PSSA/PVDF membrane consists of cross-linked polystyrene sulfonic acid (PSSA) immobilized within an electrochemically inert matrix of poly(vinylidene fluoride).

Heretofore, the fabrication of an MEA has typically involved the following process: An ink for each electrode is prepared from a combination of (a) an electrocatalyst (Pt for the cathode, Pt/Ru for the anode) and (b) a solution of a perfluoro-sulfonated ion-exchange polymer dispersed in lower alcohols. Each ink is applied to either (a) a sheet of poly(tetrafluoroethylene)-impregnated porous carbon paper or (b) a surface of a solid-electrolyte membrane. The membrane is sandwiched between the carbon papers, which are destined to become the electrodes. The sandwich, in a hydrated condition, is then pressed at a temperature of 145 to 150°C and a pressure of 2 kpsi (14 MPa).

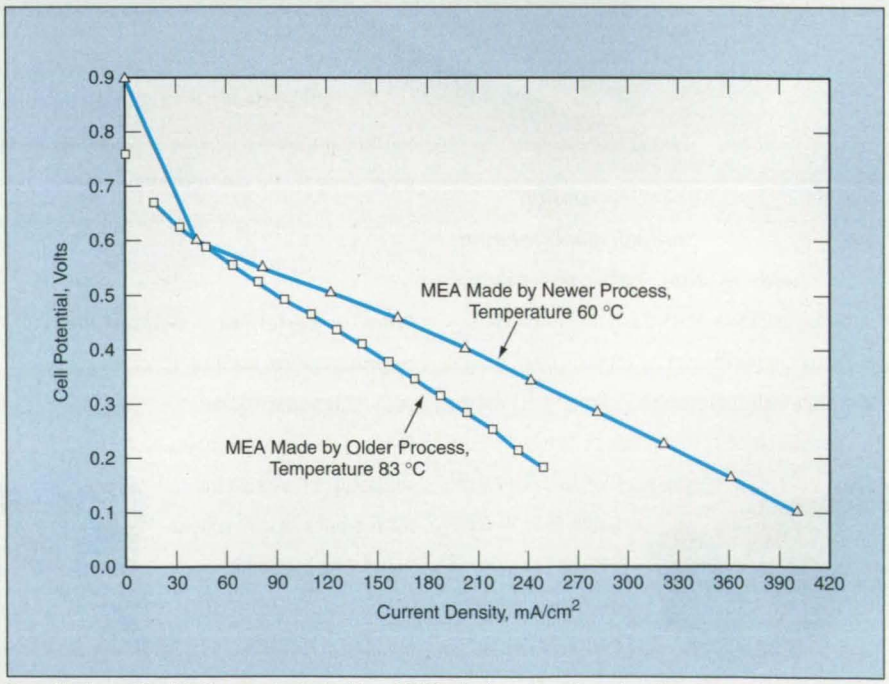
Prior to the development of PSSA/PVDF membranes, the membranes in the MEAs of the most advanced direct methanol fuel cells were made from perfluoro-sulfonated ion-exchange polymers. The principal advantage of PSSA/PVDF membranes over membranes made from those and other polymer electrolyte materials is that the PSSA/PVDF membranes are less permeable by methanol; this translates to less methanol crossover and thus greater fuel-utilization efficiency. Relative to MEAs made from perfluoro-sulfonated ion-exchange membranes, MEAs made from PSSA/PVDF membranes exhibit comparable proton conductivity and less methanol crossover. However, until now, the electrical performances of the PSSA/PVDF-based MEAs have not been adequate for use in fuel cells. The inadequacy (in particular, high electrical resistance and poor utilization of catalyst) has been attributed primarily to poor interfacial bonding of the electrocatalytic layers with the proton-conducting moieties of the membrane. This completes the background information.

The changes in the fabrication process are intended to improve the interfacial bonding and the formation of proton-conducting channels at the membrane/electrocatalyst interfaces. One of the changes is the addition of PVDF powder to the ink. The PVDF improves the interfacial bonding by making the ink more chemically and thermodynamically similar to, and thus more miscible with, the membrane. In addition, PVDF has low intrinsic permeability by methanol and thus helps suppress methanol crossover through the electrodes.

Another change is roughening the membrane prior to application of the catalytic electrode layers. Roughening enhances bonding by providing additional sites for anchoring the catalytic and polymeric electrode materials.

A third change is the addition of water and N,N-dimethylacetamide to the ink (which, in this case, is painted directly onto the membrane). These additions enhance bonding by increasing the plasticity of the membrane during hot pressing. These additions also enhance bonding by preventing undesired dryout during hot pressing.

In an experiment, the electrical performance of a fuel cell containing an MEA made by a process that incorporates these changes was measured, along



Two Methanol Fuel Cells were tested with a 1.0 M solution of methanol and oxygen at 20 psig (gauge pressure of 0.14 MPa), but at different temperatures. Even at its lower test temperature, the cell containing the MEA made by the newer process performed better.

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with that of a fuel cell containing an MEA made by an older process. The cell containing MEA made by the newer process was operated at a lower temperature, yet it exhibited better performance (see figure). Inasmuch as the performance of a given cell increases with temperature, the performance of the MEA made by the newer process could be expected to exceed that of the other MEA by an even greater margin if both were tested at the same temperature.

This work was done by Sekharipuram Narayanan and Marshall Smart of Caltech and Tony Atti, Surya Prakash, and George Olah of the University of Southern California for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

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Refer to NPO-20644, volume and number of this NASA Tech Briefs *issue, and the page number.*

Making Hydrophobic Cathodes for MEAs in Fuel Cells

Poly(tetrafluoroethylene) powder is added to catalytic inks used to make electrodes.

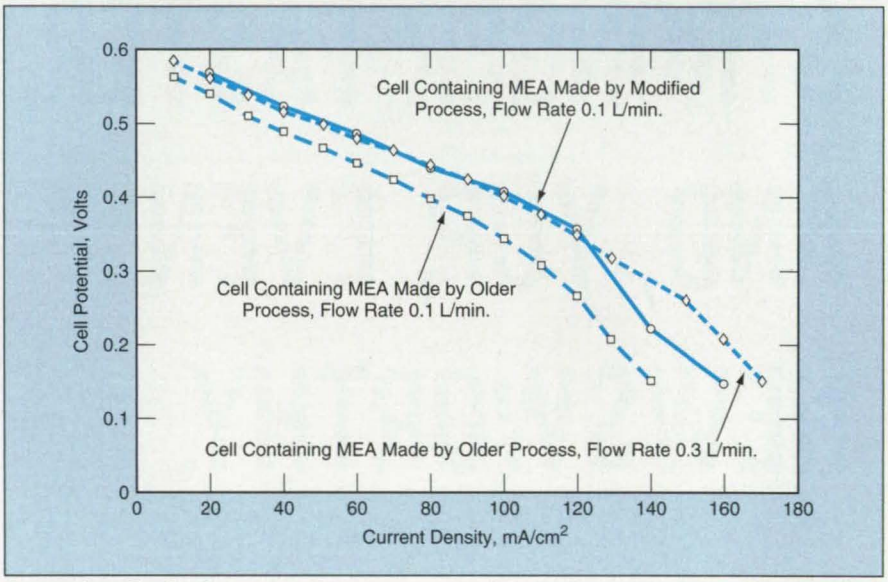
NASA's Jet Propulsion Laboratory, Pasadena, California

The fabrication of membrane/electrode assemblies (MEAs) for direct methanol fuel cells can be modified to make the cathodes hydrophobic. These modifications improve the performances of the fuel cells, as explained below.

As in the preceding article, it is necessary to present some background information in order to give meaning to a description of the modifications. During operation of a direct methanol fuel cell, water is produced at the cathode. If not removed, the water blocks access of air to catalyst sites on the cathode, and the cell output voltage is consequently decreased. At a high rate (a large multiple of the stoichiometric rate) of flow of air or oxygen past the cathode, the blockage is less severe because the excess flow evaporates the water. However, the equipment needed to pump the air and condense the evaporated water adds to the size and weight of the fuel-cell system and consumes a significant amount of power, thereby decreasing the efficiency of the fuel-cell system.

The size and weight of the system could be reduced and/or the efficiency of the system could be increased if it were not necessary to rely on evaporation to remove the water from the cathode and thus the system could be operated at a lower airflow rate. To reduce or eliminate reliance on evaporation, it would be desirable to exclude the water (or at least some of the water) from the cathode in the first place by rendering the cathode at least partly hydrophobic. The essence of the present modifications of the fabrication process is to implement this concept by adding a hydrophobic constituent to the cathode material.

The hydrophobic constituent in question is a poly(tetrafluoroethylene) powder with a particle size ranging from 1 to 4 μm. The powder is added to the catalytic inks used to make the electrodes. Each ink is applied to both (a) a sheet of poly(tetrafluoroethylene)-impregnated porous carbon paper and (b) a surface of a perfluoro-sulfonated ion-exchange membrane that has been roughened by use of abrasive paper to increase adhesion. Then as in the process described in the preceding article, the membrane is sandwiched between the carbon papers and the sandwich is consolidated by applying heat and pressure.



Two Methanol Fuel Cells were tested at a temperature of 50°C with a 1.0 M solution of methanol and flowing air. The electrode area is 25 cm^2, and the membrane used was Nafion 117 or equivalent.

In an experiment, the electrical performance of a fuel cell containing an MEA made by the modified process was tested, along with that of a fuel cell containing an MEA made by an older process. The cell containing the MEA made by the modified process performed nearly equivalently to other cell at a third of the flow rate, and performed better at the same flow rate (see figure).

This work was done by Sekharipuram Narayanan and Thomas Valdez of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

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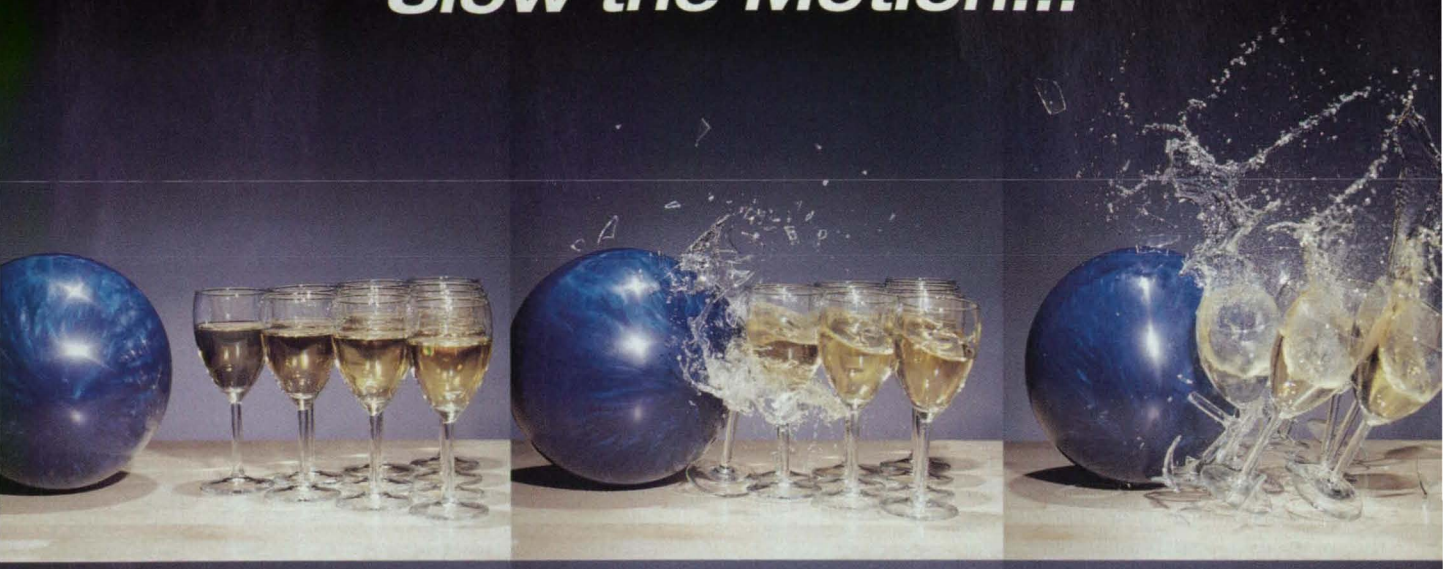

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Improved Polymer/Solid-Electrolyte Membranes for Fuel Cells

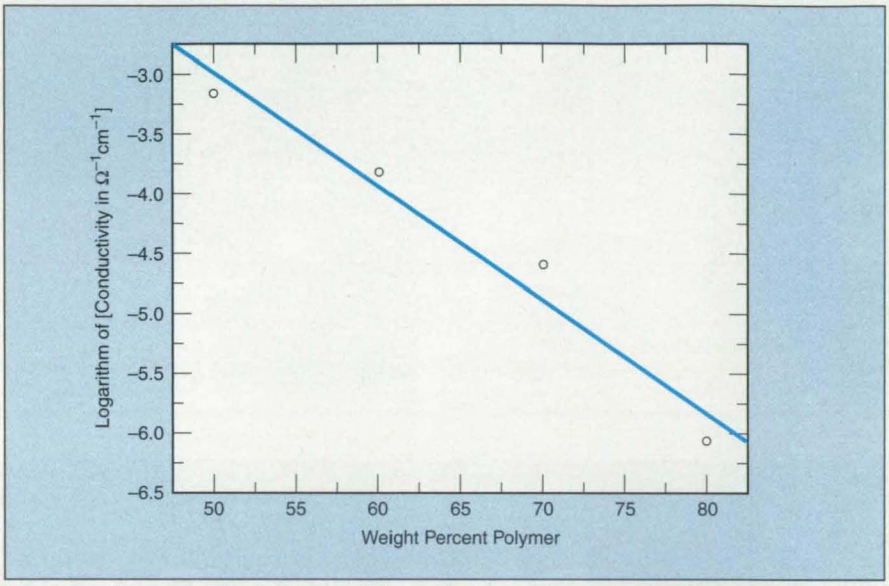
Because water would be unnecessary for proton conductivity, operating temperatures could be increased.

NASA's Jet Propulsion Laboratory, Pasadena, California

A class of developmental membrane electrolyte materials for methanol/air and hydrogen/air fuel cells is exemplified by a composite of (1) a melt-processable polymer [in particular, poly(vinylidene fluoride) (PVDF)] and (2) a solid proton conductor (in particular, cesium hydrogen sulfate). In comparison with previously tested membrane electrolyte materials, including those described in the two preceding articles, these developmental materials offer potential advantages of improved performance, lower cost, and greater amenability to manufacturing of fuel cells.

A principal limitation on the utility of the previously tested membrane electrolyte materials is that they must be hydrated to be able to conduct protons. This requirement translates to a maximum allowable operating temperature of about 90°C, and the presence of water in the polymer matrices undesirably gives rise to high permeability by methanol. It would be desirable to reduce permeability by methanol to increase cell performance and fuel-utilization efficiency, and it would be desirable to operate fuel cells at temperatures as high as 140°C to increase their tolerance to carbon monoxide from reformate streams. Therefore, what are needed are membrane materials that conduct protons in the absence of water.

In a composite material of the type undergoing development, the polymer serves as a matrix to support the solid proton conductor. In cesium hydrogen sulfate, proton conduction occurs by a mechanism that does not depend on water. At room temperature, the protons are in a bound state and so there is little or no proton conduction. However, as the temperature rises past 130°C and toward a value between 135 and 145°C, the cesium hydrogen sulfate undergoes a phase transition to a state in which the hydrogen ions have a significant amount of mobility; that is, the material becomes a proton conductor. The conductivity can be as high as 0.1 $\Omega^{-1}cm^{-1}$ — of the order of the conductivities of the previously tested membrane electrolyte materials.



The **Electrical Conductivities** of polymer/solid electrolyte composites made of various proportions of the same polymer and solid electrolyte were measured by an ac-impedance method at a temperature of 130°C.

Some experimental polymer/solid electrolyte membranes have been fabricated by mixing PVDF and cesium hydrogen sulfate powders and pressing the mixtures in a die at temperatures between 160 and 190°C. Other experimental membranes were prepared by forming slurries of the powder mixtures in organic solvents, casting the slurries on a plate, allowing the slurries to dry, and then hot pressing the slurries. The figure shows the logarithms of electrical conductivities of these membranes as a function of composition. At the time of reporting the information for this article, it was anticipated that these membranes would be used to fabricate membrane/electrolyte assemblies for testing in fuel cells.

This work was done by Sekharipuram Narayanan, Sossina Haile, Dane Boysen, and Calum Chisholm of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

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Tantalum oxide/polymer composites are molded into light-transparent plates.

Lyndon B. Johnson Space Center, Houston, Texas

Windows that absorb x rays and are transparent to visible light can be made by compression molding of tantalum oxide/polymer composite materials. The main x-ray-absorbing medium in these windows is tantalum instead of lead, which is the traditional main x-ray-absorbing medium. These composite windows have been developed to replace lead-filled glass and lead-filled polymer x-ray-absorbing windows, which are unsuitable for use in some environments because of the toxicity of lead.

The composite materials are transparent to visible light because the tantalum

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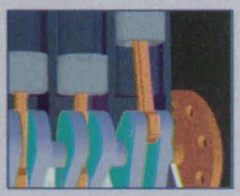

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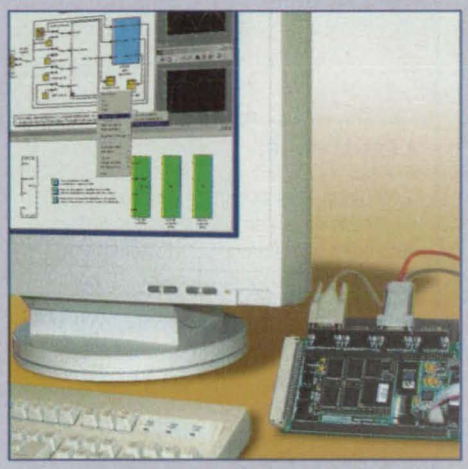

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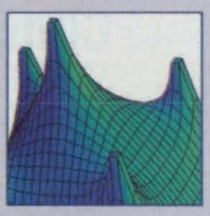

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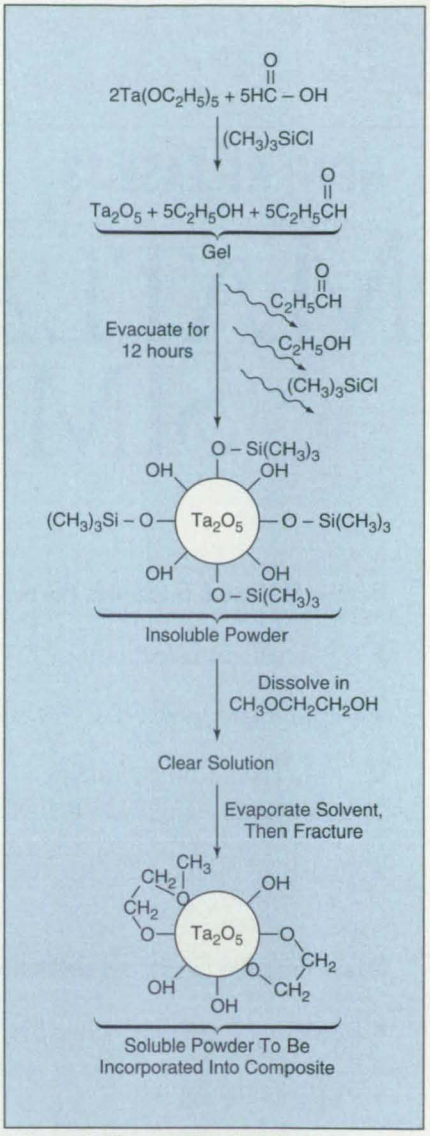
oxide is contained in oligomeric clusters much smaller than the smallest wavelength of visible light. The first step in the synthesis of the clusters (see figure) is the formation of insoluble clusters of the general composition $Ta_xO_y[OSi(CH_3)_3]_z$ by hydrolyzing $Ta(OC_2H_5)_5$ with formic acid in the presence of $ClSi(CH_3)_3$. The clusters are then rendered soluble in alcohols by reacting them with a suitable alcohol such that the trimethyl siloxy group is replaced with an alkoxy moiety from the alcohol.

The resulting soluble oligomeric tantalum oxide clusters can be mixed in any proportion with methoxyethanol solutions of phenoxy (hydroxy aryl-alkyl ether) polymer to form a clear solution that can be cast into clear films. The films can be rendered brittle by cooling them in liquid nitrogen, then fractured while still brittle to produce a molding powder. Provided that the weight percentage of the tantalum oxide component of the powder is ≤60, the powder can be compression molded at a temperature of 150°C to obtain a transparent plate. Alternatively, a film of the tantalum oxide/phenoxy composite can be cast on one of two sheets of polycarbonate of bisphenol A, then sandwiched between the two polycarbonate sheets under heat and pressure to obtain a laminated window with desirable mechanical and optical properties.



Oligomeric Clusters That Contain Ta_2O_5 are synthesized and made into an alcohol-soluble powder in this sequence of reactions.

This work was done by Stephen T. Wellinghoff of Southwest Research Institute for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

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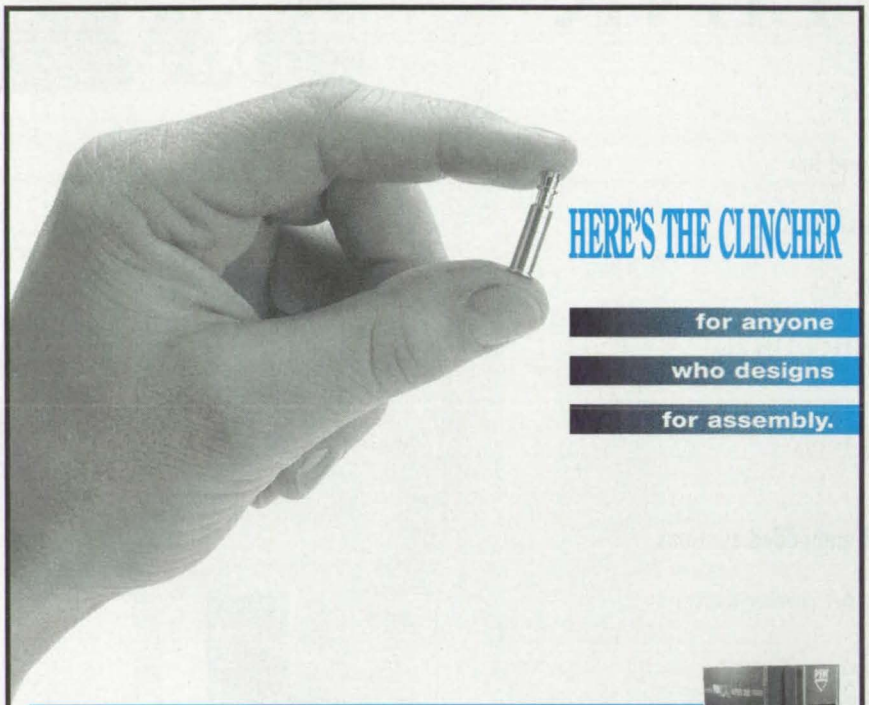

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Computational Test Cases for Oscillating Clipped Delta Wing

These data can be used to test computational simulations of aerodynamic behavior.

Langley Research Center, Hampton, Virginia

Computational test cases have been selected from archived sets of data acquired some years ago in wind-tunnel experiments on a clipped delta wing equipped with a hydraulically actuated trailing-edge control surface. In some of the experiments, the wing was subjected to pitching oscillations and control-surface oscillations. (The wing was stiff and thus did not undergo appreciable elastic oscillations; instead, it was mounted in such a way as to enable it to oscillate as a rigid torsionally sprung body.) The data obtained in the experiments included the static pressures and the real and imaginary parts of the first harmonics of dynamic pressures at a number of points on the upper and lower wing surfaces.

The significance of the experiments and the computational test cases lies in the design of the wing and in the need for experimental data to verify computational fluid dynamics (CFD) programs for use in analyzing and designing similar wings. The planform of the wing was derived by simplifying the planform of a proposed design for a supersonic transport airplane. A strake was deleted, the resulting planform was approximated by a trapezoid with an unswept trailing edge, and the twist and camber were removed. To facilitate pressure instrumentation, the thickness of the wing was increased to 6 percent of chord, as compared with 2.5 to 3 percent for the supersonic transport. The airfoil as thus designed had a symmetrical circular-arc section.

One of the consequences of increasing the relative thickness of a clipped delta wing is that transonic effects are enhanced for mach numbers near one; these effects are significantly stronger than would be the case for the thinner supersonic-transport wing. Also, the combination of the high (50.5°) leading-edge sweep and the sharpness of the leading edge results in the formation of a leading-edge vortex on the wing at relatively low (of the order of 3°) angles of attack. In addition, a shock develops over the aft portion of the wing at transonic speeds such that at some angles of attack, there is both a leading-edge vortex and a shock wave on the wing. Such cases pose a computational challenge.

The particular selection of test cases was made to illustrate trends for a variety of static, pitching-oscillation, and control-surface-oscillation conditions, with emphasis on effects associated with transonic flows. The dynamic cases were chosen for evaluation of unsteady effects under the corresponding nominally static conditions. The selection provides for parametric variation of the static angle of attack, frequency of pitching oscillation, frequency of control-surface oscillation, and mach numbers from subsonic to low supersonic values.

This work was done by Robert M. Bennett and Charlotte E. Walker of **Langley Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*

L-17822

Control Derivatives of the F-18 Airplane

These derivatives will be used in designing an active-aeroelastic-wing control system.

Dryden Flight Research Center, Edwards, California

Flight data gathered by use of the F-18 System Research Aircraft (SRA) based at Dryden Flight Research Center have been used to estimate stability and control derivatives for a baseline F-18 airplane. The data were obtained in the high-dynamic-pressure range of the F-18 flight envelope in an experiment performed in support of a future F-18 program to be devoted to the concept of the active aeroelastic wing (AAW). The AAW technology is intended to integrate aerodynamics, active controls, and aeroelasticity in such a way as to maximize the performance of the airplane. More specifically, the goal of the AAW project will be to maximize the contribution of a reduced-stiffness F-18 wing to roll-rate performance.

In order to support the AAW technology, changes in flight-control computers and software will be required, and an understanding of the effectiveness of each control surface under various conditions is essential. The experiment on the SRA was performed to obtain this understanding. The results of the experiment can be used to update a mathematical model of the aerodynamics of the F-18 airplane, which model can be used to improve the control laws under development for the AAW version of the F-18 airplane.

In the experiment, an onboard excitation system (OBES) was used to provide uncorrelated single-surface input (SSI) doublet sequences. Longitudinal maneuvers included leading-edge flap (LEF), trailing-edge flap (TEF), symmetric aileron, and symmetric horizontal-tail SSIs. Lateral-directional maneuvers included rudder, differential LEF, differential TEF, aileron, and differential tail SSIs. The pilot initiated each sequence of maneuvers from the cockpit and the OBES commanded the SSI doublets. During some maneuvers, the control surfaces were moved in combinations not used by the basic F-18 control laws: these included symmetric LEF, TEF, and aileron deflections at high speeds.

The data acquired during flight were analyzed afterward by use of an output-error parameter-estimation algorithm. A complete set of experimental stability and control derivatives was obtained for tests performed at 20 different combinations of mach number and altitude. A complete set of nominal control derivatives for these test conditions was also ob-

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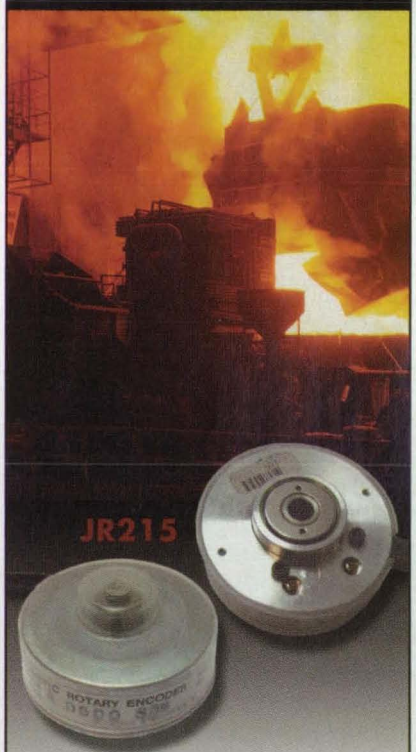

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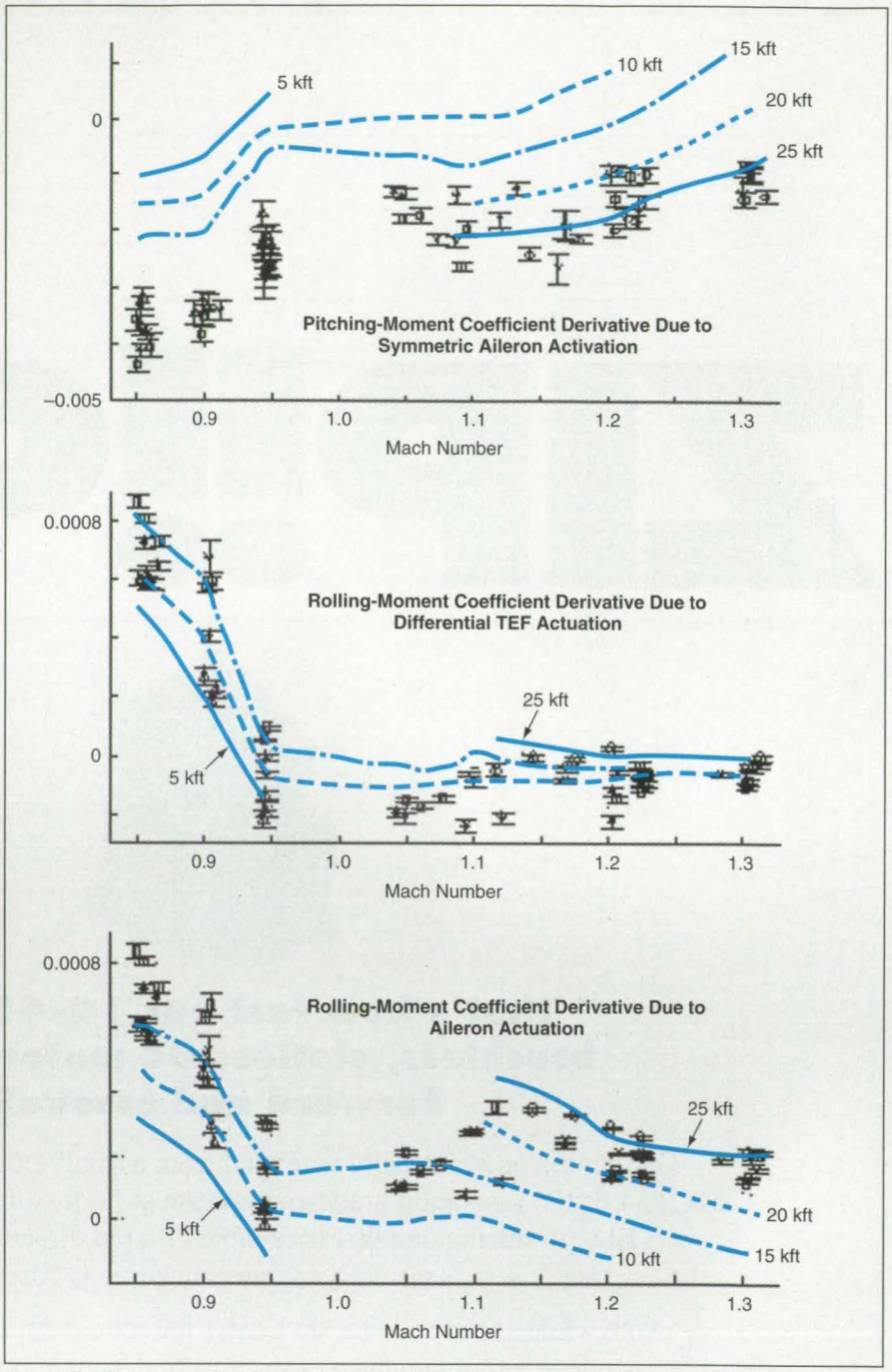


These **Stability and Control Derivatives** of the F-18 airplane are a few of those obtained from flight-test and computational-simulation data. The lines represent the computational-simulation values for the noted altitudes.

tained from computational simulations. For example, the top part of the figure shows the effect of symmetric aileron deflection on pitching moment. In this plot, the magnitude of the experimental pitching-moment effectiveness can be seen to exceed that obtained by computational simulation, which is represented by lines for various altitudes between 5,000 and 25,000 ft (1,524 and 7,620 m), especially at low mach numbers.

Control-surface rolling-moment "reversal" was of special interest to the project. The middle and lower parts of the figure show TEF and aileron rolling-moment derivatives. For example TEF reversal was revealed by the flight data acquired at mach 0.95 at altitudes below 10,000 ft (3,048 m). The flight data did not reveal aileron reversal, but did show that aileron effectiveness was reduced by increasing the mach number (especially in the subsonic range) and reducing the altitude.

This work was done by Tim Moes and Gregg Noffz of **Dryden Flight Research Center**. *For further information, contact the Dryden Commercial Technology Office at (661) 276-3689.*
DRC-01-32

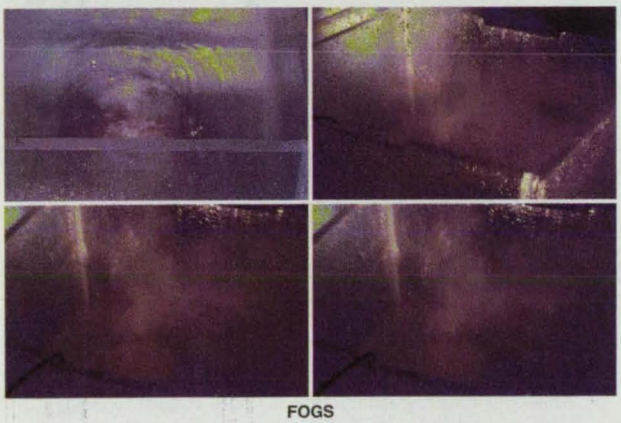
Ultrasonically Induced Fountains and Fogs

Diverse visual effects could be produced in computer-controlled displays.

NASA's Jet Propulsion Laboratory, Pasadena, California

Experiments have demonstrated the feasibility of generating fountains and fogs over a body of water (see Figure 1) by utilizing high-intensity ultrasound to induce acoustic streaming, cavitation, and atomization. The transducer used in the experiments had a 10-cm diameter and a 10-cm focal length, was immersed in water at a depth approximately equal to its focal length, and was excited at various amplitudes and at various frequencies from 100 kHz to 2 MHz. It was observed in the experiments that the fountain and fog effects depend on the amplitude and frequency of excitation.

FOUNTAINS



FOGS

Figure 1. **Fountains and Fogs** were induced over a water bath by ultrasound generated by a focusing transducer immersed in the bath.

Through suitable control of the excitation waveforms applied to multiple immersed ultrasonic transducers, it should be possible to create, destroy, enlarge, diminish, or otherwise change fountains and fogs to produce diverse visual effects for artistic display. Optionally, a fountain-and-fog display generated in this manner could be synchronized with illumination and/or with music. Scattering of light from water columns, water drops, and fogs could be exploited to obtain striking visual effects.

An apparatus proposed for implementing this concept is called an ultrasonically induced plumbing-free switchable multi-fountains and fog (ULIFOG) system. In addition to ultrasonic transducers immersed in a water bath, a ULIFOG sys-

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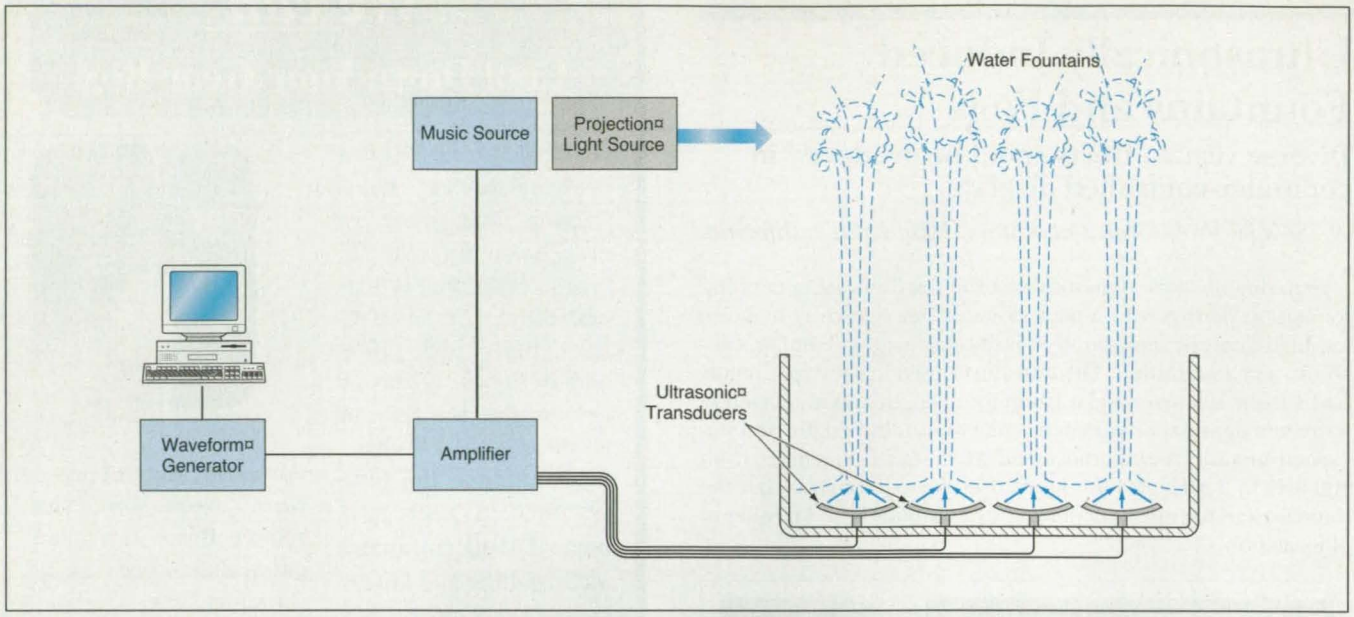

Figure 2. A **ULIFOG System** would exploit effects like those of Figure 1 in synchronism with lighting and sound effects.

tem (see Figure 2) would include (1) electronic circuits to excite the ultrasonic transducers with waveforms chosen to produce the desired fountain and fog effects, (2) one or more source(s) of light (e.g., lasers or colored lamps), (3) a source of music, and (4) a computer that would control the aforementioned subsystems and would coordinate the visible and audible aspects of the display.

The mechanical simplicity occasioned by elimination of the need for pipes, valves, and pumps is an advantage over prior fountain display systems. Another advantage over such systems is much faster response: For example, in an ULIFOG system, one could change a fountain into a fog in a millisecond by switching the frequency of excitation of the applicable transducer.

This work was done by Yoseph Bar-Cohen and Stacey Walker of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Mechanics category.*
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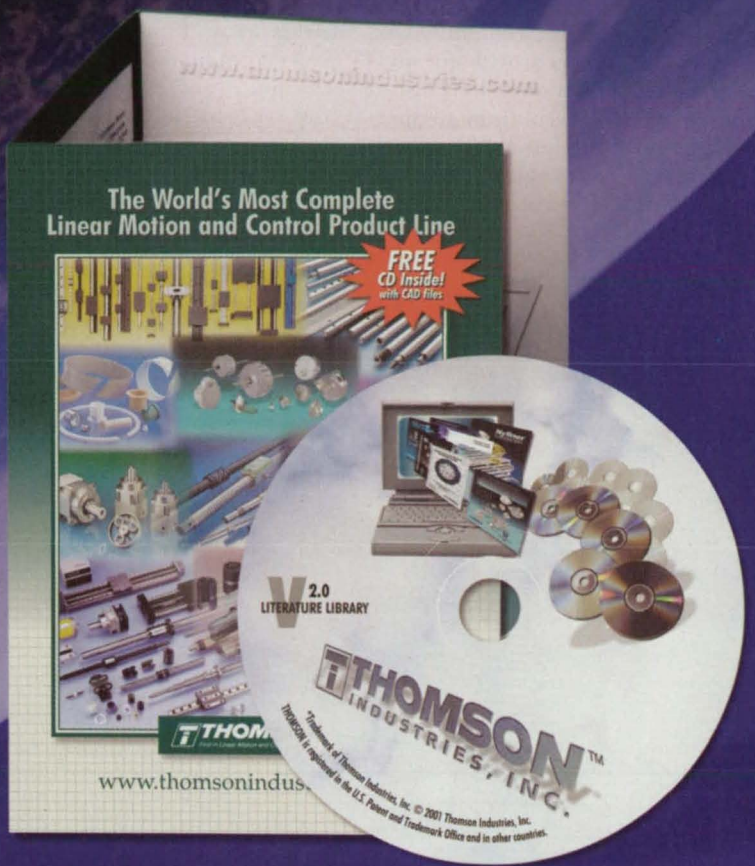

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Fail-Safe, Continue-to-Operate Concept for Jackscrews

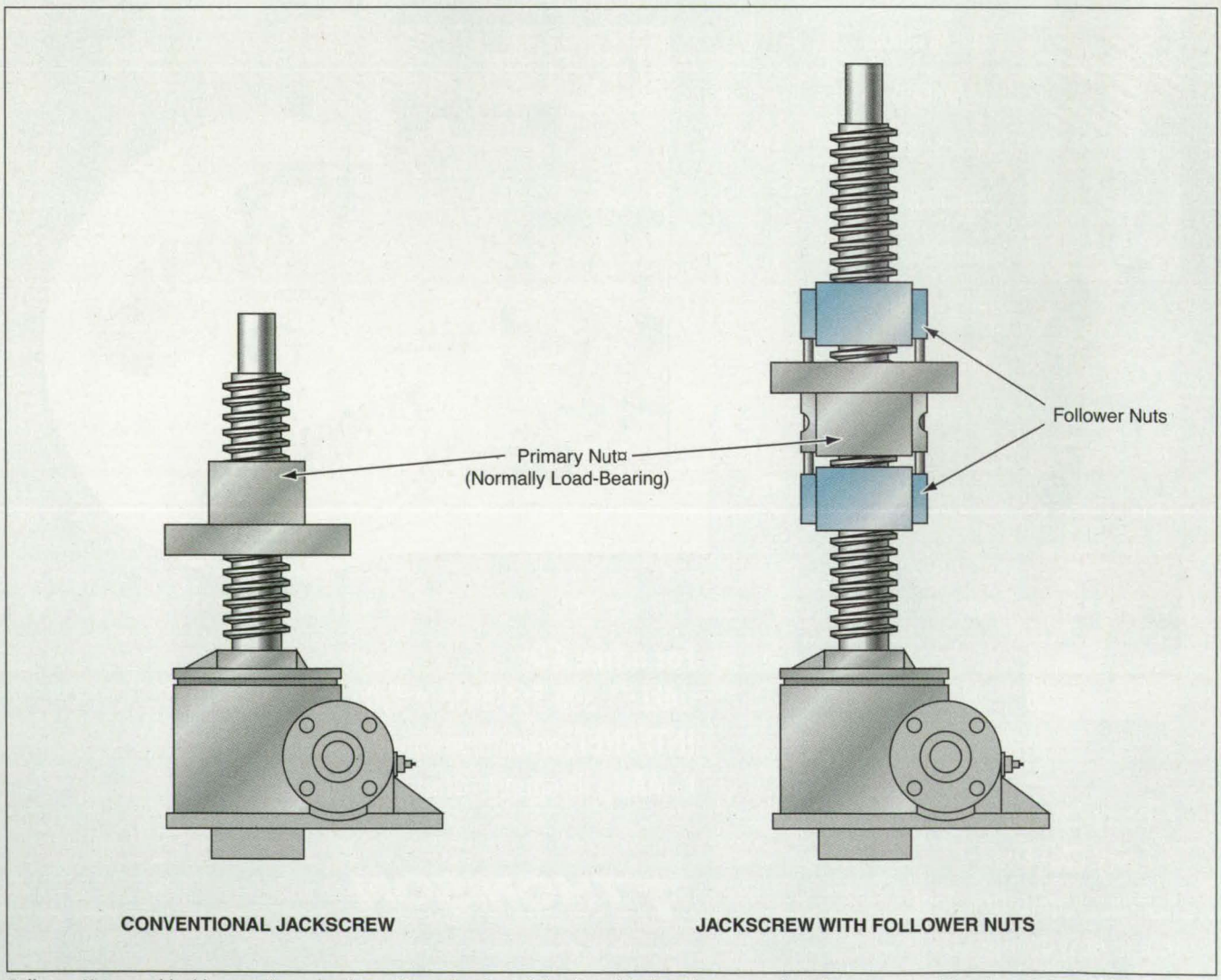
Redundant nut increases reliability and facilitates inspections.

John F. Kennedy Space Center, Florida

A fail-safe, continue-to-operate design concept for machine jackscrews calls for the incorporation of a redundant follower nut that would assume the axial jack load upon failure of the primary nut. Heretofore, the way to design for increased reliability of jackscrews has been to provide for multiple jackscrews operating in unison. The present fail-safe, continue-to-operate design concept offers an alternative for preventing catastrophic failures in jackscrews, which are used widely in aeronautical, aerospace, and industrial applications.

A conventional jackscrew contains only one nut made of a material softer than that of the threaded shaft. With prolonged use, the thread in the nut wears away. If not inspected and replaced when wear becomes excessive, the nut eventually fails by shearing of the thread under load. A typical jackscrew according to the present fail-safe, continue-to-operate concept would include a redundant follower nut in addition to the primary nut. The follower nut is mechanically attached to the primary nut and free to move axially relative to the primary nut. The follower nut would bear no axial load and would have negligible wear as long as the primary nut continued to function normally.

In the absence of thread wear and play, the follower nut would be axially separated from the primary nut by a distance comparable to the thread pitch. Increasing wear would cause a change in



Follower Nuts would add protective redundancy. Upon shearing of the thread in the primary nut, the primary nut would push against one of the follower nuts, causing that nut to bear the load.

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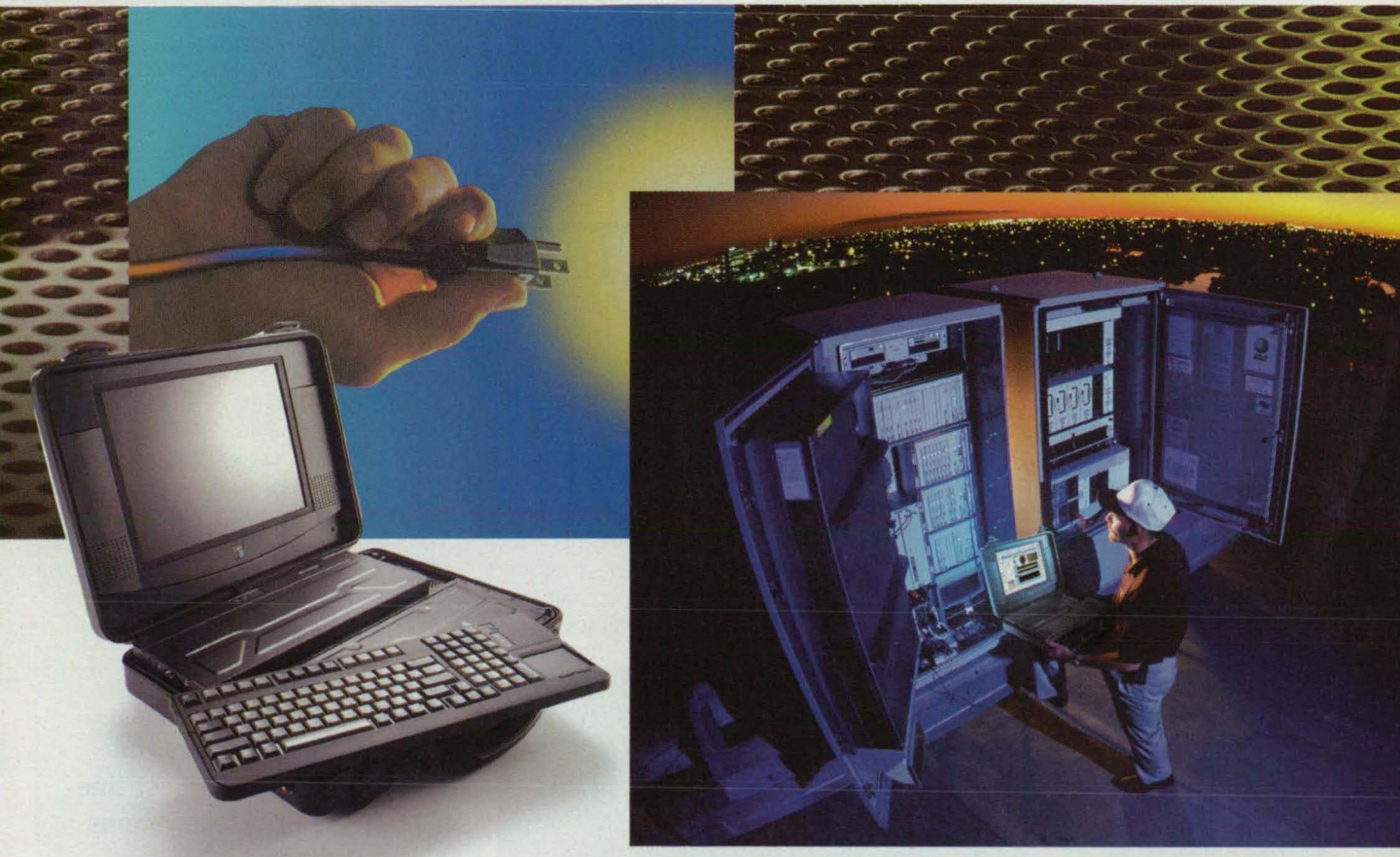

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this distance that would be taken as an indication of the amount of wear prior to failure of the primary nut. The redundant follower nut assumes the axial load in the event of primary nut wear and subsequent thread shear failure. Hence, the jackscrew would continue to operate with the follower nut bearing the load until a repair could be made.

Unlike the case of a conventional jackscrew, it would not be necessary to relieve the load to measure axial play or disassemble the nut from the threaded shaft to inspect for wear. Instead, wear could be determined by measuring the axial gap between the primary and follower nut. This could be accomplished by visual inspection, or possibly with the help of a simple measuring tool. Another option could incorporate electronic or mechanical wear indicators to monitor the gap during operation and assist during inspection. These devices would be designed to generate a warning when the thread was worn to a predetermined thickness. Note: A half-thickness value is the wear tolerance recommended by major manufacturers of jackscrews.

The fail-safe, continue-to-operate concept applies to all types of machine jackscrew designs. It can be applied equally well to ball screw jacks.

This work was done by John G. Fraley, Ivan Velez, and Charles G. Stevenson of **Kennedy Space Center** *and Richard T. Ring, Jr., and Ralph Webber of United Space Alliance. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*

KSC-12187/291/92

Pulse-Tube Refrigerator for Liquid Hydrogen

An unusually high operating frequency enables reductions of size and weight.

Marshall Space Flight Center, Alabama

An improved closed-loop, two-stage pulse-tube refrigerator provides 4 W of cooling power at a temperature of 15 K. The original intended application of this refrigerator is in preventing boiloff of liquid hydrogen from a propellant tank aboard a spacecraft. The basic refrigerator design can also be adapted to terrestrial applications like cooling superconducting electronic devices.

The design operating frequency of this pulse-tube refrigerator is 30 Hz — an order of magnitude greater than the operating frequencies of other pulse-tube refrigerators. The higher frequency makes it possible to design a compressor that is much smaller and lighter, relative to the compressors of lower-frequency pulse-tube refrigerators of similar capacity.

This work was done by W. G. Dean of Dean Applied Technology Co., Inc., for **Marshall Space Flight Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*

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Ultrasonic/Sonic Vibrating/Rotating Tool Bits

Teeth are made asymmetric to induce rotation without need for rotary actuators.

NASA's Jet Propulsion Laboratory, Pasadena, California

An easy-to-implement design concept shows promise for improving the performances of impact tool bits used in abrading surfaces, drilling, and coring of rock and rocklike materials. The concept is especially applicable to tools actuated with a combination of ultrasonic and sonic vibrations, as in the cases described in "Ultrasonic/Sonic Drill/Corers With Integrated Sensors (NPO-20856), *NASA Tech Briefs*, Vol. 25, No. 1 (January 2001), page 38. Such tools were originally intended to be used in scientific drilling and coring of rock; they might also be useful for drilling, coring, and surface grinding of rock for art and construction.

When teeth of a tool of this type are symmetric, the tool tends not to rotate. In the absence of rotation, the hammering action of the tool against the rock face causes the tool to dig a footprint that includes holes that mate with the teeth. A footprint is generally undesired for two reasons: (1) usually, one seeks uniformity of the abraded or drilled surface; and (2) once the tool settles into the footprint, the impact forces become spread over the tooth and footprint surfaces, with consequent reductions in tooth impact stresses and, hence, reduction in the rate of removal of rock.

The present design concept is simply to make the teeth asymmetric, so that the hammering action of the tool against the rock face gives rise to a net torque that causes the tool to rotate, even in the absence of a rotary actuator (see figure). The rotation prevents the formation of a footprint, thereby helping to ensure that contact between the tool and the rock takes place predominantly at the tooth tips, with consequent concentration of impact forces at tooth tips and, hence, higher impact stresses resulting in a greater rate of removal of rock.

This work was done by Benjamin Dolgin, Stewart Sherrit, Yoseph Bar-Cohen, Stephen Askins, Deborah Sigel, Xiaoqi Bao, and Zensheu Chang of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Machinery/Automation category.*
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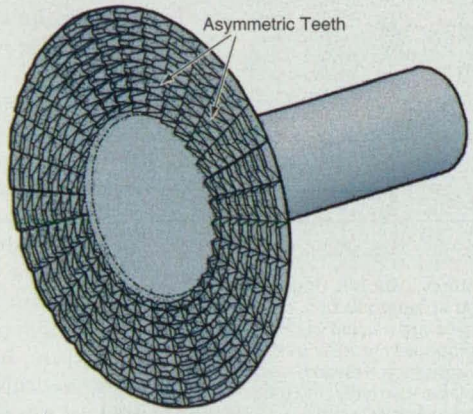
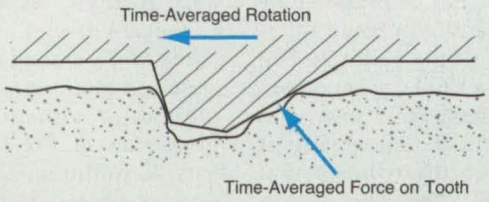


ABRASION BIT



ENLARGED CROSS SECTION SHOWING ONE TOOTH IN OPERATION

The **Asymmetry of the Teeth of an Abrasion Bit** typically gives rise to a torque that, averaged over time, causes the bit to rotate as indicated. On hard rock, the direction of rotation could change to the opposite of that shown here.

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Noninvasive Assessment of Human Fine Motor Control

Lyndon B. Johnson Space Center, Houston, Texas

A report presents additional information about the Impairscope — an instrument for noninvasive measurement of fine neuromuscular control and, more particularly, for quantifying the degradation of neuromuscular performance under psychological stress. The instrument, previously called the "Neuroskill device," was described in "Biometric Instrument Measuring Neuromuscular Disorder/Performance Degradation (MFS-26449), *NASA Tech Briefs*, Vol. 21, No. 11 (November 1997), page 40. To recapitulate: The instrument includes an instrumented pen that measures motions along the two axes perpendicular to its long axis and the axial force with which the pen is pressed against a writing surface. The measurements are digitized 200 times per second and processed by software that implements an advanced method of correlation-function analysis to generate measures of the stability, smoothness, and synchronization of handwriting movements. The instant report reiterates information from the cited previous article, discusses the shortcomings of prior techniques for assessing effects of stress on motor control, briefly describes an underlying theory of the granular stationarity of the statistical properties of handwriting dynamics, and summarizes results of an experiment in which Impairscope measurements showed a degradation of handwriting performance in a group of students under the stress of final examinations.

This work was done by Ruth Shrairman and Alexander Landau of VeriFax Corp. for **Johnson Space Center**. *To obtain a copy of the report, "Non-Invasive Method For Assessment of Human Fine Motor Control," access the Technical Support Package (TSP)* ***free online at www.nasatech.com/tsp*** *under the Bio-Medical category.*

MSC-23030

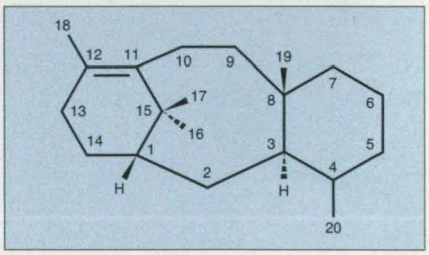
Enhanced Bioproduction and Extraction of Taxanes

Potential anticancer drugs can be produced without destroying endangered trees.

Lyndon B. Johnson Space Center, Houston, Texas

Several groups of methods of enhanced bioproduction and extraction of taxanes have been invented. Taxanes (see figure) have exhibited potential as drugs for treatment of cancer and congenital polycystic kidney disease. One taxane — paclitaxel (more widely known under the trade name Taxol™) — has been approved by the Food and Drug Administration for treatment of several types of cancer. Currently, paclitaxel and other taxanes are produced by extraction and by semisynthesis from precursor taxanes isolated from *Taxus* sp. The present inventive methods are intended to enable the production of taxanes and related products in quantities sufficient for testing them as potential anticancer drugs, without destroying *Taxus* trees. In addition, the methods afford versatile capabilities for tailoring the chemical structures of taxanes and related products to maximize their beneficial effects.

One group of methods exploits the discovery that haploid and haploid-derived cultures of cells of any plant of the genus *Taxus* can produce taxanes. More specifically, female gametoyphytic tissues taken from immature seeds can be cultured to produce significant amounts of taxanes. The method of acquiring the tissues for culturing includes sterilization of seed surfaces and careful dissection to keep diploid cells (in which taxane production may in some cases be inhibited by dominant and quantitative gene interactive effects) out of the cultures. The cultures are grown under aseptic conditions that are monitored and controlled. One essential component of control is the use of culture media that do not contain nitrates. The growth process can include aging until the culture reaches a condition regarded as optimum (e.g., a condition that favors steady-state production of taxanes).



A **Taxane Molecule** features a tricyclic ring nucleus. Enhanced methods of bioproduction, such as the ones described here, are needed because some taxanes are not produced naturally in the quantities needed for anticancer research and totally synthetic production currently involves too many steps to be commercially feasible.

Once a desired cell culture has been established, it can easily be scaled up for growth in a bioreactor to produce taxanes in larger quantities.

Taxanes can be recovered from cell cultures by one or more of methods or combinations of methods, some of which were previously established, others of which are parts of the present invention. Established methods include the use of absorbent beads, the use of adsorbent particulate material released by cultured cells, and the use of solvents to extract taxanes from the aforementioned beads and particles. Methods that are parts of the present invention include enzymatic treatments, hydrolysis under suitably controlled acid or alkaline conditions, and controlled use of radiation or heat. In the cases of taxanes that are chemically bound in cells or cell fragments, such extraction may give rise to chemical alterations that could be exploited to enhance the beneficial properties of the final taxane products. In addition, alkaloids related to taxanes can be produced by the aforementioned methods.

Another group of methods, which amounts to a generalization of the aforementioned group of methods, is

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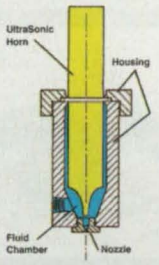


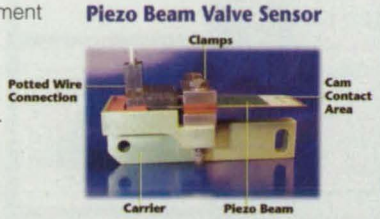
Kimberly Clark's patented technology uses ultrasonic energy to improve efficiency and throughput for both equipment suppliers and end users who spray or extrude fluids of all types through nozzles. This unique ultrasonic nozzle system is self-cleaning and delivers improved spray properties, a more regulated spray, and a number of other benefits. This technology can be used in any industry involved with spraying fluids, from automotive to plastic processing to hot melt application to chemical processing -- in almost every case the spray efficiency and effectiveness can be improved. **http://www.yet2.com/nasatech/209**

Low Cost, Low Density Ceramic Fibers Perfect Replacement for Costly Superalloys and Ceramics

Bayer AG has developed low cost, low density ceramic fibers exhibiting superior high temperature mechanical properties compared to superalloys and existing ceramic fibers. These fibers are used to manufacture ceramic matrix composites which have major applications in aerospace and power generation, where it is anticipated that significant operational cost reductions can be achieved through weight saving and higher thermal efficiencies. SIBORAMIC is corrosion resistant and lightweight – providing weight reductions of approximately 40% compared to other ceramic fibers and as much as 70% compared to typical superalloys. **http://www.yet2.com/nasatech/210**

Piezo-Beam Sensor Ideal Low Cost, Hi Rel Solution For Critical Position Indicator Systems

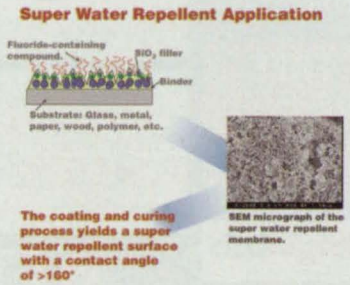
Honeywell is offering cutting edge technology for position sensing systems. Currently used on aircraft to sense valve positions, this unique device utilizes a sensor beam in an instrument which is low cost, lightweight, modular, and able to operate reliably in extreme engine environments. The "piezo-beam" has no electrical contacts--a substantial improvement over conventional position sensors. The device is lightweight and inexpensive, with few parts and an interchangeable, modular design for easy replacement during maintenance. A standardized design enables it to be used in a wide variety of applications, enabling high volume manufacturing with reduced production costs and higher margins. Its potential applications are extensive, including aircraft environmental control system valves, commercial HVAC systems, CNG processing and safety controls, gas and fluid transfer systems, and many more. **http://www.yet2.com/nasatech/211**



Versatile, Super Water Repellent Can be Controlled by Light

Hitachi has invented a robust, fluorine-containing compound that could provide superb water-repellency for a wide range of materials and products while remaining active for longer periods of time. This organic surface treatment utilizes commercially available chemicals applied in a relatively straightforward process.

The flexibility and versatility of this technology make it suitable for a broad range of applications, including anti-corrosion coatings, electronics packaging, architectural coatings, anti-icing treatments, fabric coatings, heat exchange surfaces, low-friction coating for machine parts and as a protective layer for recording media, to name a few. A variation of the technology enables the degree of water repellency to be controlled by exposure to light. **http://www.yet2.com/nasatech/212**



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based on the observation that taxanes can be obtained from parts of a tree other than bark and seeds and from conifers other than those of the genus *Taxus*. These methods include (1) antibody-based screening methods to identify conifer tissues that contain taxanes and (2) taxane-recovery methods include extraction by use of solvents, enzymatic treatments, and hydrolysis.

A third group of methods, embodying a further generalization, is based on the concept of obtaining taxanes from any plant capable of producing them. This group includes antibody-based screening methods to identify taxane-producing plants, methods to isolate taxane-producing cells from cultures, methods of stimulating taxane production through control of physical and chemical conditions in cultures, and methods of extraction. Among the methods of isolating taxane-producing cells from a culture, the one that is preferred involves the use of paramagnetic beads to which are bound molecules of an antibody that recognizes another antibody that, in turn, binds taxanes that are present in or on cell walls. The cells thus isolated can then be cultured under controlled conditions for enhanced production of taxanes.

This work was done by Don J. Durzan and Frank F. Ventimiglia of the University of California for **Johnson Space Center.**

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

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Refer to MSC-23442/151/152, volume and number of this NASA Tech Briefs *issue, and the page number.*

Steam Sterilization of a Packed Column Without Admitting Air

Lyndon B. Johnson Space Center, Houston, Texas

A procedure has been devised for the use of steam to sterilize a water-purification cartridge, chromatographic column, or other closed packed column that is required to be kept filled with water and from which it is required to exclude air bubbles, which could impede flow. For the purpose of this procedure, the column must be equipped with valves and quick-disconnect fittings at both ends. First, the column is flushed and filled with distilled water. The outlet of the column is then connected to a tube, the other end of which is open and is placed at the bottom of a bottle partly filled with distilled water. More distilled water is flushed from the inlet, then through the column, outlet, and tube, into the bottle. The inlet valve is closed and disconnected from the source of water, the column is placed on a stand in an autoclave with the outlet valve open, and the autoclave is activated through its heating cycle. After cooldown from the heating cycle, the outlet valve is closed and disconnected from the column, which is now sterile and filled with distilled water.

This work was done by Richard L. Sauer, Duane L. Pierson, and Jose G. Limardo of **Johnson Space Center** *and David W. Koenig and Paul Mudgett of KRUG Life Sciences. For further information, access the Technical Support Package (TSP)* ***free online at www.nasatech.com/tsp*** *under the Bio-Medical category.*

MSC-22760

Water-Microbiology Kit

Samples can be analyzed conveniently in the field.

Lyndon B. Johnson Space Center, Houston, Texas

Materials and equipment for determining whether samples of potable water contain harmful microbes have been packaged in a kit. Designed for use aboard spacecraft, the kit is also suitable for terrestrial use in a laboratory or in the field. The kit holds the sample, nutrient, and waste liquids in a closed system.

The kit is based on a traditional technique that involves membrane filtration to separate microbes from the water sample, followed by growth of

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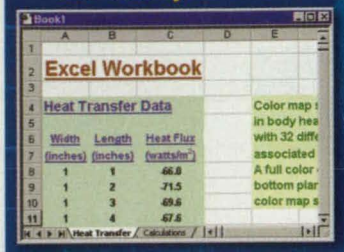

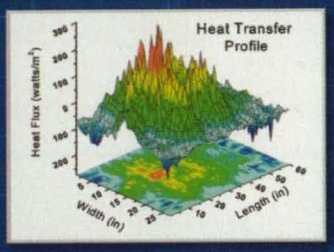

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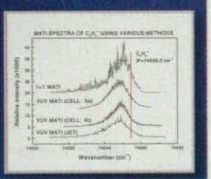
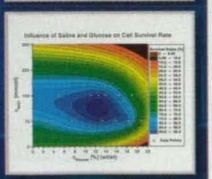
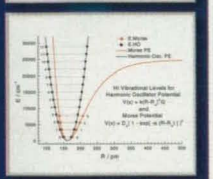
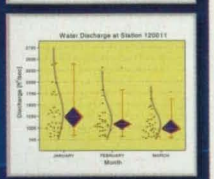

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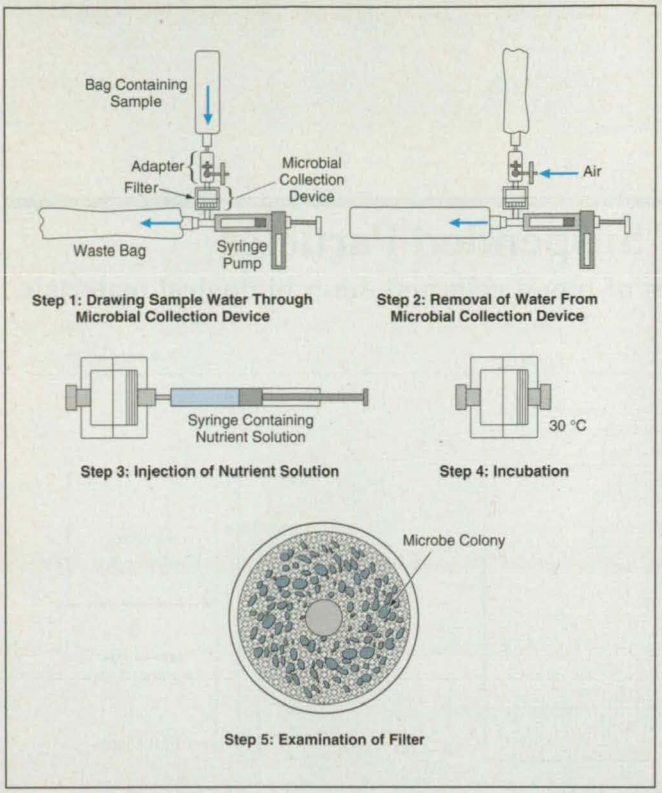

A **Water Sample Is Filtered** through a microbial capture device. A nutrient solution is then injected into the device, and the device is incubated. After incubation, the number of colonies that grew from the captured microbes is counted.

the microbes under favorable nutrient and temperature conditions. The resulting colonies of microbes are counted and recorded as an indication of the microbial content of the sample.

A water sample is collected in a small plastic bag. The bag is then connected to one end of an adapter unit that includes a valve. The other end of the adapter unit is connected to the inlet of a microbial capture device, which is a small in-line-filter chamber that contains (1) a cellulose acetate filter with an effective pore size of 0.45 μm and (2) an absorbent pad for subsequent retention of a nutrient solution in contact with the filter. A syringe pump and a waste bag are connected to the outlet of the microbial capture device; the syringe pump is used to draw sample water from the collection bag through the filter and into a waste bag (see figure). As sample water flows through the filter, microbes from the water become trapped in the filter.

Once the specified amount of sample water (typically, 100 mL) has been drawn through the filter, the microbial capture device is disconnected from the other devices. The nutrient solution, which is prepackaged in a syringe, is injected into the microbial collection device, which is then placed in an incubator at a temperature of 30°C, or else left at room temperature, if an incubator is not available. After incubation for 48 h at 30°C or 72 to 96 h at room temperature, the filter is examined; the number of bacterial colonies (which appear as blue dots) is counted and recorded.

This work was done by Duane L. Pierson and Richard L. Sauer of **Johnson Space Center** *and David W. Koenig, D. Bell-Robinson, S. M. Johnson, and Saroj K. Mishra of Krug Life Sciences, Inc. For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Bio-Medical category.*

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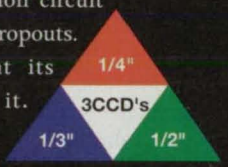

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Optical Fourier-Plane Analysis of Suspended Particles

This technique would be used to diagnose samples of blood cells and other biological materials.

Lyndon B. Johnson Space Center, Houston, Texas

Optical Fourier-plane analysis may prove useful for obtaining statistical data on the densities, sizes, shapes, indices of refraction, and perhaps other properties of particles (particularly, biological cells) suspended in liquids. This concept could potentially be the basis of a new class of simple, portable, relatively inexpensive instruments for diagnosis of samples of blood and other biological materials.

As currently envisioned, the concept involves placement of the sample of liquid/particle suspension in a specially designed transparent two-piece acrylic container. One of the pieces is said to be lenticular because its inner face features a linear array of grooves like the grooves of a diffraction grating or the Fresnel analog of a cylindrical lens (see Figure 1). The sizes and shapes of the grooves may or may not change incrementally along the array, depending on the specific application. Typically, the lineal density of channels is 100 to 200 per inch (about 40 to 80 per centimeter).

The other piece of the container includes a flat plate that covers the grooves, leaving the ends of the grooves open. This other piece can also include a handle for holding the container and an area for placing a drop of the liquid/particle suspension to be analyzed. Once placed, the liquid moves to and fills the grooves by capillary action.

The filled container is positioned in the apparatus shown in Figure 2, at the focal point of the Fourier-transform lens. The container is illuminated with light from the laser. The intensity in the resulting Fourier-transform image is measured as a function of position along an axis perpendicular to the grooves. This measurement is performed by use of a photodetector with a slit aperture in the Fourier-transform plane; the photodetector is moved along this axis by use of a translation stage. The relative intensity measured as a function of position constitutes a Fourier signature that can be analyzed to determine the relative concentrations of particles (cells) of various sizes.

The feasibility of this concept was demonstrated in preliminary experiments

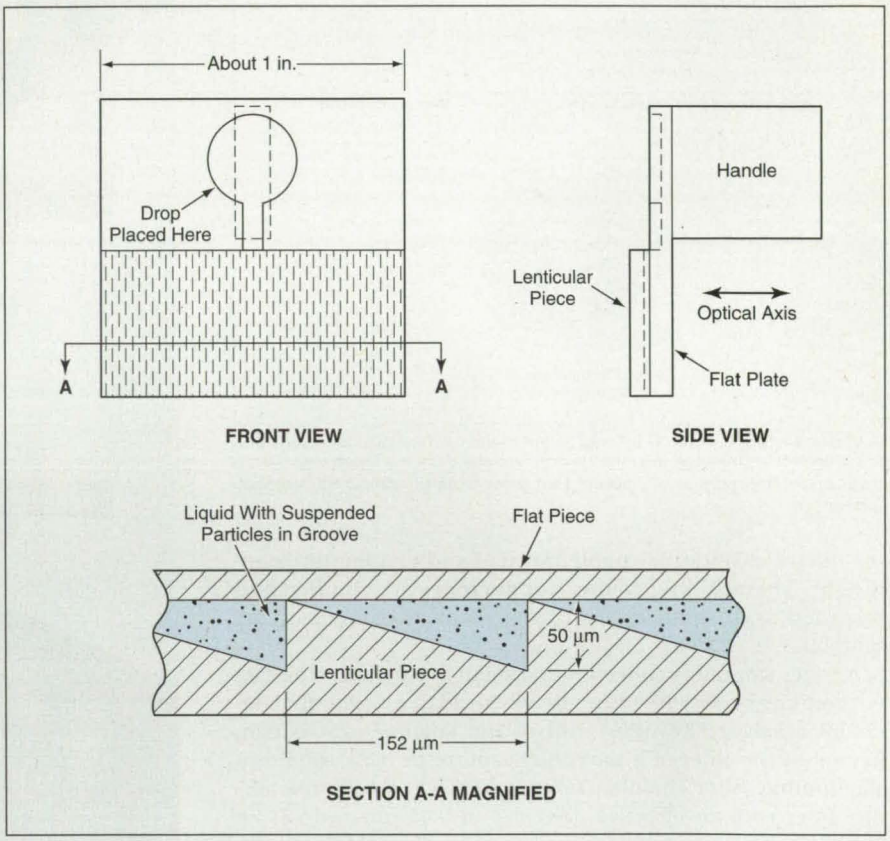

Figure 1. A **Liquid Containing Suspended Particles** is placed in a container, one of the inner faces of which is grooved.

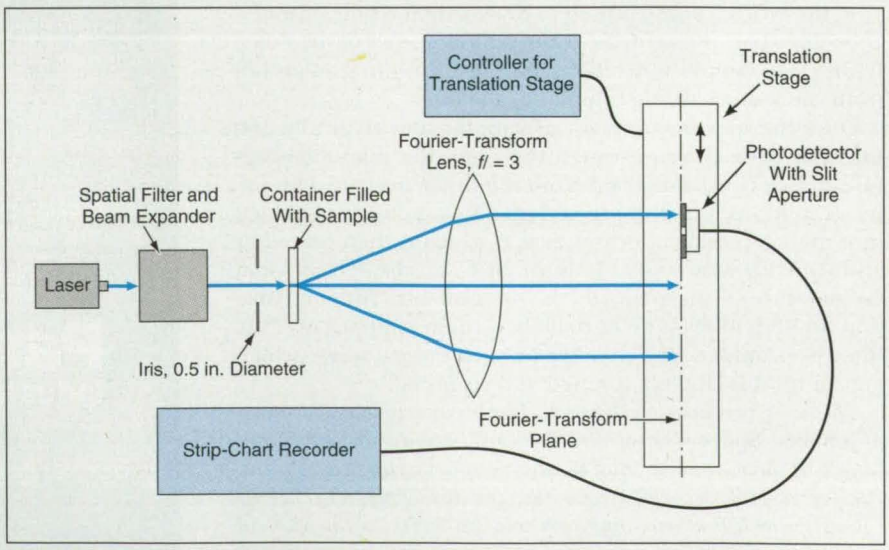

Figure 2. The **Fourier-Transform Image** of a filled container like that of Figure 1 is scanned to obtain statistical data on the suspended particles.

on suspensions of microspheres with diameters of 2, 4.5, and 15 μm. The best results were obtained with a lenticular piece featuring a prismatic groove pattern — the sawtooth pattern shown in Figure 1. Each suspension was found to produce a unique and repeatable Fourier-transform signature. Similar results were obtained in preliminary experiments on samples of blood.

This work was done by Steven H. Mersch of Point Source, Inc., for **Johnson Space Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

In accordance with Public Law 96-517, the contractor has elected to retain title to this invention. Inquiries concerning rights for its commercial use should be addressed to

Mr. Steven Mersch
Point Source
1864 Dayton Pike
Germantown, OH 45327
Telephone No: (513) 855-6020

Refer to MSC-22575, volume and number of this NASA Tech Briefs *issue, and the page number.*

Preparing High-Quality Micrographic Samples of Oil Paintings

Cross-sectional specimens are prepared with wet grinding followed by dry polishing.

John H. Glenn Research Center, Cleveland, Ohio

A technique similar to that of metallography has been devised for preparing cross-sectional micrographic specimens from small samples cut from oil paintings. Art experts at the Cleveland Museum of Art use the technique in their efforts to determine painters' methods and to verify the authenticity of paintings. By implementing the technique with automated polishing equipment, they can prepare a cross-sectional specimen in 20 min, and a publication-quality photomicrograph (see figure) can be made from the specimen. In contrast, the prior manual preparation technique took about 4 h and yielded specimens that contained scratches and were not flat enough for viewing at higher magnifications.

The technique is applied to a small (< 0.2 mm) sample that is removed from the painting with a scalpel. The sample is cast in polyester resin in a standard metallographic mount. The mount is then ground and polished in two stages to expose the desired cross section. The first stage involves traditional grinding with silicon carbide abrasive papers in water lubricant at a normal force of 200 N; a succession of four ever finer papers is used, starting with 320 grit and ending with 2,400 grit. The grinding time at each of the first three grits is automatically limited to 30 s. The grinding at 2,400 grit is stopped when the ground surface is within 10 μm of the sample, as measured by bright-field and polarized-light microscopy.

The second, more delicate, stage involves dry polishing; that is, dry grinding with a succession of even finer grits. First, silicon carbide in six steps of 1,500 through 6,000 grit is used, followed by aluminum oxide of 8,000, then 12,000 grit. Dry grinding must be used in exposing the cross section of the sample because some layers of the paint may be soluble in water, ethanol, kerosene, and other traditional grinding and polishing lubricants. A normal force of 10 N is applied in this stage. The grinding times are 10 s for each of the first three SiC grits, 15 s

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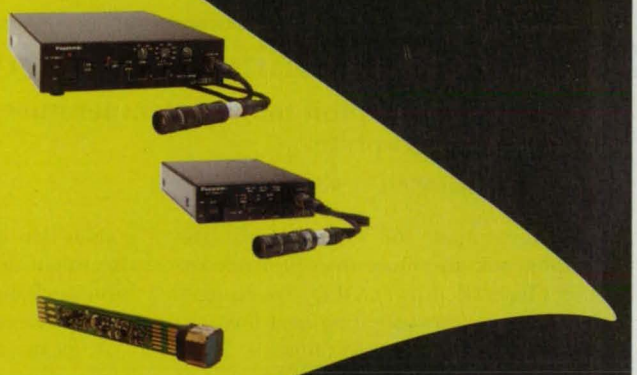

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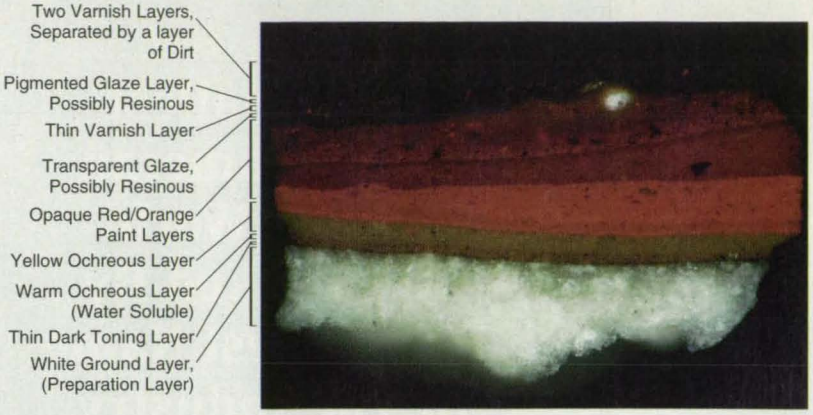


Paint Layers Are Intact and clearly visible in a polarized-light micrograph of a cross-sectional specimen taken from an oil painting.

for each of the second three SiC grits, and 20 s for each of the Al_2O_3 grits. The resulting surface is highly polished and suitable for photomicrography.

This work was done by Todd Leonhardt of NYMA, Marcia Steele of the Cleveland Museum of Art, and William Waters of Waters and Associates for **Glenn Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to the Patent Counsel, Glenn Research Center; (216) 433-2320. Refer to LEW-16177.

Pyrolytic-Graphite Gauges for Measuring Large Heat Fluxes

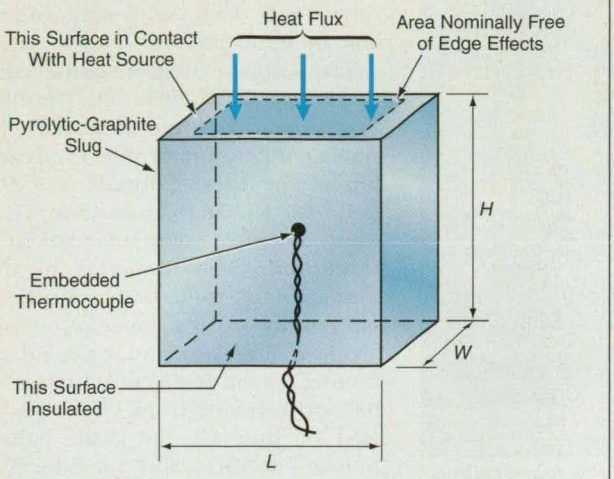
These gauges exploit the high-temperature endurance and thermal-conduction anisotropy of pyrolytic graphite.

Marshall Space Flight Center, Alabama

Gauges made of slugs of pyrolytic graphite with thermocouples embedded in them have been invented for use in measuring large, short-duration heat fluxes in hot, highly corrosive environments. These gauges were originally intended for use in combustion chambers of rocket engines; they might also be useful in terrestrial combustion chambers (e.g., in furnaces) and metal-processing equipment.

A gauge of this type is basically a calorimeter with a thermal mass large enough that its thermal-transient-decay time is significantly greater than the duration of the heat flux that one seeks to measure. One surface of the slug is placed in contact with the surface across which one seeks to measure the heat-flux density; the opposite surface of the slug is kept insulated. Then given the mass and specific heat of the slug and assuming that the slug is approximately isothermal at any given instant, the net flux of heat into the slug can be estimated as the product of the mass of the slug, the specific heat of the slug, and the rate of change of temperature as measured by the thermocouple in the slug. Then given the area through which heat flows into or out of the slug on the surface of interest, the heat-flux density is given simply by the estimated flux divided by this area.

As described thus far, the slug could be made of any of a variety of thermally conductive materials. The reasons (other than high-temperature endurance and resistance to corrosion) for making the slug out of pyrolytic graphite are best explained by the example of the figure. Pyrolytic graphite exhibits anisotropic thermal conductivity: its conductivity is high (comparable to that of copper) in two perpendicular directions and low (about $10^{-2}\times$ as much) in the third perpendicular direction. In this case, the material in the slug is oriented so that the high conductivity is along the H and L axes and the low conductivity along the W axis. The high conductivity along the H and L axes helps to keep thermal gradients within the slug small, thereby making the response of the thermocouple fairly in-



This **Slug-Type Heat-Flux Gauge** exploits the anisotropic thermal conductivity of pyrolytic graphite. Here, the high-conductivity dimensions are *H* and *L*, and the low-conductivity dimension is *W*.

sensitive to its depth within the slug and justifying the assumption of isothermality. The low thermal conductivity along the *W* axis makes it possible to fabricate the slug as a plate that is thin along the *W* axis while still avoiding thermal gradients that would otherwise be caused by edge effects.

This work was done by Robert C. Bunker, Mark E. Ewing, and John L. Shipley of Cordant Technologies for **Marshall Space Flight Center**.

Title to this invention has been waived under the provisions of the National Aeronautics and Space Act {42 U.S.C. 2457(f)} to Thiokol Propulsion. Inquiries concerning licenses for its commercial development should be addressed to

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Refer to MFS-31572, volume and number of this NASA Tech Briefs *issue, and the page number.*

Wind and Mountain Wave Observations From a Flight Test of a Solar-Powered Airplane

This airplane was shown to be useful for observing atmospheric waves.

Dryden Flight Research Center, Edwards, California

In support of NASA's Environmental Research Aircraft and Sensor Technology (ERAST) program, flight tests of the Pathfinder solar-electric-powered, remotely piloted aircraft (RPA) were conducted at the Navy's Pacific Missile Range Facility (PMRF), Barking Sands, Kaua'i, Hawaii, from May to November 1997 and from June to August 1998. This airplane was designed to operate at low speeds and low Reynolds numbers for long duration at altitudes above 60,000 ft (18 km). Three successive altitude world records for propeller-driven aircraft were established during these tests: 67,400 ft (20.54 km) on June 9, 1997; 71,350 ft (21.75 km) on July 7, 1997; and 80,201 ft (24.445 km) on August 6, 1998.

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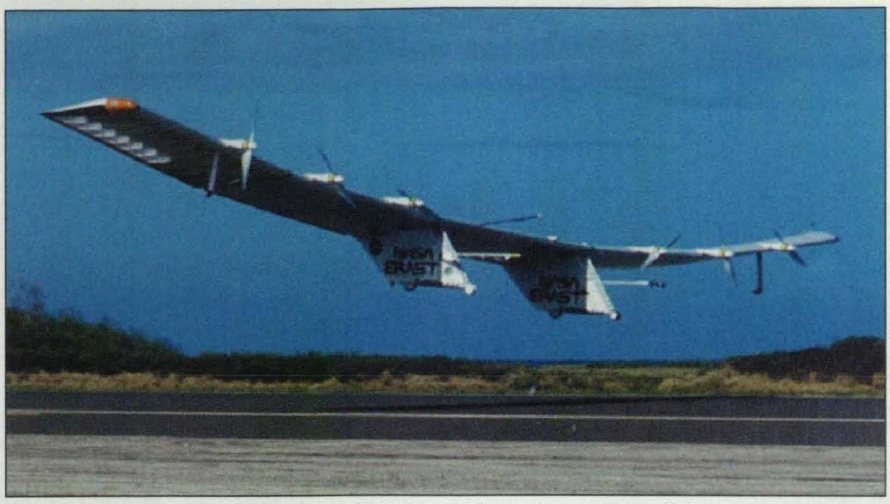

Figure 1. The **Pathfinder Solar-Powered Airplane** is shown here taking off for its record-breaking flight on June 9, 1997.

The 1997 Pathfinder airplane was of a flying-wing configuration (see Figure 1) with a span of 99 ft (30 m) and a chord of 8 ft (2.4 m). With a nominal gross weight of 500 lb (mass of 227 kg), the wing loading was extremely light — less than 0.64 lb/ft^2 (30.6 Pa). The airplane was propelled by 6 electric motors powered by a solar-cell array on the upper surface during the day and by batteries at night. The airplane had an equivalent airspeed of 17 knots (8.7 m/s) with an overall climb and descent rate of nominally 220 ft/min (1.1 m/s). The airplane was designed to carry a payload of as much as 50 lb (23 kg) to high altitude for studies of the atmosphere and ecosystem and for development of sensors.

The extremely light wing loading made the airplane highly responsive to gusts and highly sensitive to winds during takeoff and landing as well as during pre- and post-flight ground handling. Wind speeds aloft that exceed the true airspeed of the airplane could be expected to make it difficult to navigate to desired and approved regions of airspace.

During descent from the record altitude on June 9, 1997, the airplane encountered a mountain-wave updraft near an altitude of 9,600 ft (2.9 km) approximately 3 nmi (5.6 km) west of the Kaua'i coastline. The remainder of this article describes the observations made in connection with this encounter. A brief description of the local geography is prerequisite to a meaningful report of the observations: PMRF is situated on the west side of the island of Kaua'i. The 5,200-ft (1.6-km) Mt. Waialeale and a north/south mountain ridge line divide the island in half 16 mi (26 km) to the east. The mountain and ridge line block and divert the easterly trade winds. Lihue lies to east of the Mountain and ridge line.

Early on June 9, 1997, weather conditions were considered acceptable for a Pathfinder flight: At 06:00 Hawaii standard time (HST), surface winds at PMRF were light and variable — perfect for rolling the airplane out and preparing it for takeoff. All upper-level winds were below aircraft true-airspeed limits as measured by the PMRF 02:05 HST and 04:38 HST rawinsonde balloons. The National Weather Service (NWS) had forecast that during the next 24 hours, upper-level winds would decrease slightly while "trade" winds at Lihue would increase slightly. Surface winds at PMRF were expected to increase to 10 knots (5 m/s) by noon and then slowly decrease to light and variable by 19:00 HST.

The airplane first encountered the updraft at 21:15 HST. The conditions near encounter time indicated a very stable temperature profile, winds at the top of the ridge [altitude > 5,000 ft (>1.5 km)] near 15 knots (8 m/s), and wind direction perpendicular to the ridge line. Measurements of these winds came from three sources: airplane onboard instrumentation [true-airspeed indicator and a Global Positioning System (GPS) receiver], a NWS balloon released from Lihue at 02:00 HST on June 10, and PMRF balloons released at 19:14 HST on June 9 and 05:38 HST on June 10.

Data from the GPS receiver and from a ground-based radar tracking system were used to reconstruct the horizontal and vertical components of the position and velocity of the airplane. During the 15 minutes following the initial encounter, the wave slowly lifted the airplane 900 ft (274 m) at a rate of 60 ft/min (0.3 m/s), as shown in Figure 2. While in the wave updraft, the airplane maintained this rate of climb. After leaving the wave, the airplane descended at a rate of 300 ft/min (1.5 m/s), which likely included the effect of a downdraft. Thus, the overall variation in the rate of climb was 360 ft/min (1.8 m/s) — twice as great as indicated by the balloon closest to the encounter

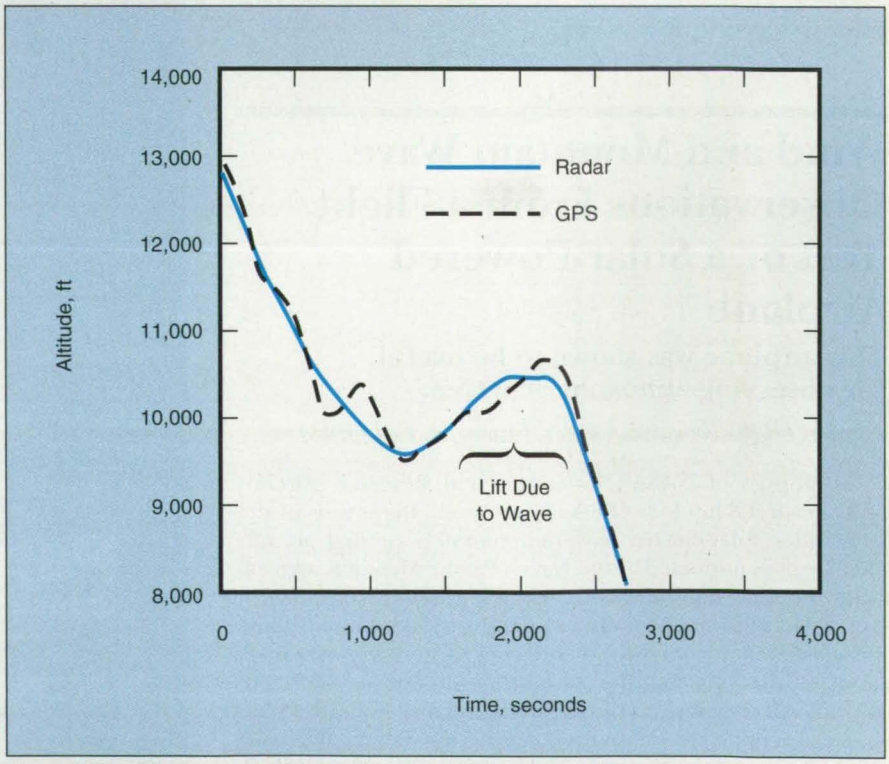

Figure 2. The **Altitude History** of the portion of the flight that included the encounter with the wave was reconstructed from radar and GPS readings.

time, but considerably less than that indicated by the last balloon above an altitude of 14,000 ft (4.3 km).

These observations indicate that the climb and descent performance of the Pathfinder airplane is a sensitive observation tool for the study of weak or light wave activity. Conversely, the sensitivity of Pathfinder to weak wave motion indicates the value of closely monitoring the meteorological profile for conditions that favor the development of waves and the importance of extracting the rates of rise of balloons from rawinsonde releases. On subsequent Pathfinder flights, balloon rise rates were monitored and analyzed for indications of up- and downdrafts. Advising flight planners and mission managers of the possibility of encountering waves enables them to account for anomalous climb- and descent-rate behavior. In addition, it makes them better prepared to navigate successfully through such phenomena to obtain additional flight time that may be needed prior to landing.

This work was done by Edward H. Teets, Jr., of Analytical Services and Materials, Inc., and Natalie Salazar of New Mexico University for **Dryden Flight Research Center**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
DRC-98-82

Electrostatic Systems Keep Dust Off Surfaces

These lightweight systems operate unattended and contain no moving parts.

NASA's Jet Propulsion Laboratory, Pasadena, California

Electrostatic dust-collection systems that comprise wire grids connected to lightweight, low-power high-voltage sources have been invented for preventing the accumulation of dust on surfaces. Intended originally for use in keeping spacecraft solar panels free of dust, these systems could also be used on Earth to keep dust off such critical surfaces as those of semiconductor surfaces that await processing, highly sensitive optical instruments, and optoelectronic devices.

The wire grid in a system of this type is strung over the surface to be kept clean, then charged to a high potential to remove any dust from the surface by electrostatic attraction. Unlike prior systems developed to keep surfaces free of dust, systems of this type both contain no moving parts and can operate unattended.

This work was done by Brian Wilcox, R. Scott Cozy, and Mike Newell of Caltech for **NASA's Jet Propulsion Laboratory**. *For further information, access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Physical Sciences category.*
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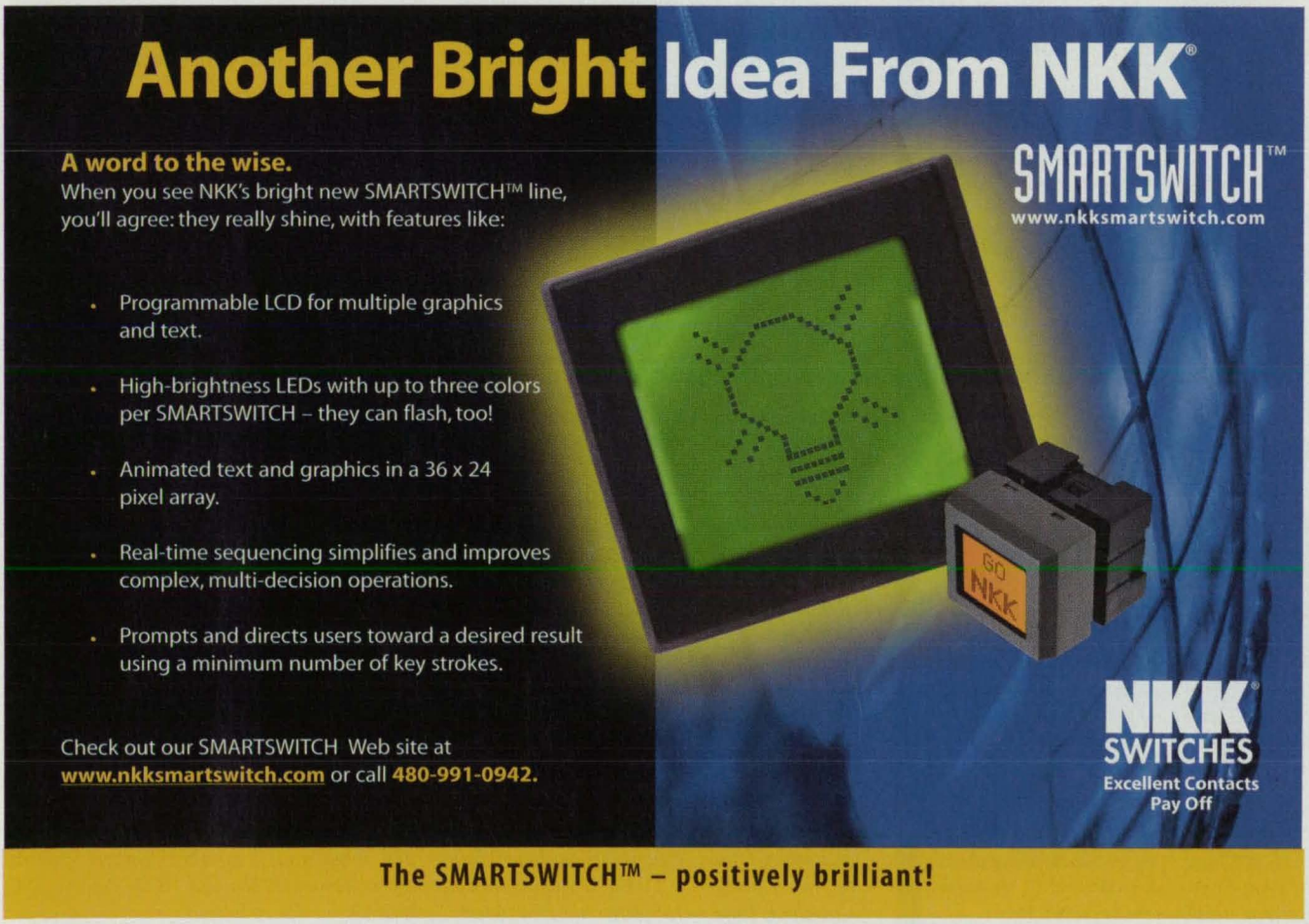

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Books & Reports

Research on Life-Prediction Methods for MMCs—Phase I

A report describes the completed first phase of a NASA/industry cooperative program of research on metal-matrix composites (MMCs) as lightweight, strong, high-temperature-resistant materials for use in future aircraft engines. The first phase of the research included assessment of life- and fracture-prediction methods, determination of fracture strengths and fatigue lives, and experiments in nondestructive evaluation. The metal-matrix composite specimens used in these studies were rings made of silicon-carbide-based fibers in a titanium-alloy matrix. The particular composite material was chosen because extensive data on the material were already available and the material is representative of composites that would be used in aircraft engines. Five fracture- and life-prediction analysis methods were applied to the rings; their predictions were compared with each other and with experimental data on fracture of the rings. Manufacturing defects prevented the researchers from conducting planned cyclic tests. Fatigue-life predictions ranged from 1,000 to 15,000 cycles. Fracture-stress predictions were less scattered, ranging from 25 to 40.1 kpsi (172 to 276 MPa). Low-resolution x-ray computed tomography proved to be an effective nondestructive-evaluation technique.

This work was done by Erwin V. Zaretsky, John Gayda, Steven M. Arnold, George Y. Baaklini, Harold E. Kautz, Frederic A. Holland, Jr., Matthew E. Melis, Gary R. Halford, Christos C. Chamis, Pappu L. N. Murthy, Bradley A. Lerch, and Carol Vidoli of **Glenn Research Center**; *Michael G. Castelli and Surendra N. Singhal of NYMA, Inc; Robert E. deLaneuville, Phillip W. Gravett, and Larry D. Percival of United Technologies, Inc.; Robert N. Yancey of Advanced Research and Applications Corp.; and Thomas E. Wilt of the University of Toledo. To obtain a copy of the report, "MMC Life System Development (Phase I)—A NASA/Pratt & Whitney Life Prediction Cooperative Program," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Materials category.*

Inquiries concerning rights for the commercial use of this invention should be addressed to NASA Glenn Research Center, Commercial Technology Office, Attn: Tech Brief Patent Status, Mail Stop 7–3, 21000 Brookpark Road, Cleveland, Ohio 44135. Refer to LEW-16464.

Wavelet-Based Time-Varying Models of Pilots in Control Loops

A report presents a study of the use of wavelet-based mathematical models to quantify the responses of humans in control loops. The report begins with a review of the traditional representation of manual control responses by use of transfer functions derived from Fourier transforms, which, the report notes, are not adequate to represent the temporally varying human responses observed in practice. Some basic principles and equations of wavelet transforms are presented.

This work was done by Martin Brenner of **Dryden Flight Research Center** *and Peter M. Thompson and David H. Klyde of Systems Technology, Inc. To obtain a copy of the report, "Wavelet-Based Time-Varying Human Operator Models," access the Technical Support Package (TSP)* ***free on-line at www.nasatech.com/tsp*** *under the Information Sciences category. DRC-01-56*

Statistical Sampling of Tide Heights Study

The goal of the study was to determine if it was possible to reduce the cost of verifying computational models of tidal waves and currents. Statistical techniques were used to determine the least number of samples required, in a given situation, to remain statistically significant, and thereby reduce overall project costs. Commercial, academic, and Federal agencies could benefit by applying these techniques, without the need to "touch" every item in the population. For example, the requirement of this project was to measure the heights and times of high and low tides at 8,000 locations for verification of computational models of tidal waves and currents. The application of the statistical techniques began with observations to determine the correctness of submitted measurement data, followed by some assumptions based on the observations.

This work was done by Merlon M. Hines of Lockheed Martin Corp. for **Stennis Space Center**.

Inquiries concerning rights for the commercial use of this invention should be addressed to the Intellectual Property Manager, Stennis Space Center; (228) 688-1929. Refer to SSC-00152.

New LITERATURE

Electric and Gear Motors

A four-page brochure from Power Electric, Plymouth, MN, describes electric motors and gear motors for OEM applications. Motor types include stepper, brushless, permanent magnet DC, geared, permanent split capacitor, pancake, timed motors, shaded pole, induction, synchronous, and actuators. **For Free Info Visit www.nasatech.com/pe**

Monitors and Controllers

The "Critical Environment Solutions" engineering binder and CD-ROM from TSI, Shoreview, MN, includes product descriptions and specifications for EverWatch®, SureFlow™, and PresSura™ monitors and controllers. Users can select flow tracking, direct pressure, or adaptive offset control using electric or pneumatic actuators, dampers, venturi valves, and airflow stations. **For Free Info Visit www.nasatech.com/tsi**

Force Sensors

Muse Measurements Corp., San Dimas, CA, has released a catalog detailing load cells and force measurement products for OEM applications. The catalog includes specifications such as capacity, dimensions, temperature effect span, temperature effect zero, output, hysteresis, and non-linearity. **For Free Info Visit www.nasatech.com/muse**

Power Components

Tyco Electronics Power Components, Menlo Park, CA, has released a brochure highlighting its Raychem Circuit Protection PolySwitch™ polymetric positive temperature coefficient (PPTC) circuit protection devices, SiBar™ thyristor surge protectors, and protected power switches and CoEv™ magnetic components. The devices are suitable for battery and portable electronics, telecommunications, networking equipment, computers, and automotive applications. **For Free Info Visit www.nasatech.com/tycopc**

Component Manufacturing

OEMetrix, Floral Park, NY, offers literature describing manufacturing capabilities for metal stampings, zinc and aluminum die casts, investment casts, aluminum extrusions, CNC turned and machined parts, and brass forgings and extrusions. The company offers press capacity to 500 tons for stampings and component assemblies in mild and alloy steel, stainless steel, aluminum, brass, and plastic materials. **For Free Info Visit www.nasatech.com/oemetrix**

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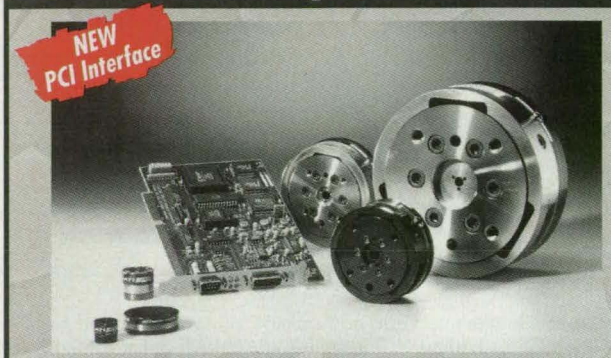

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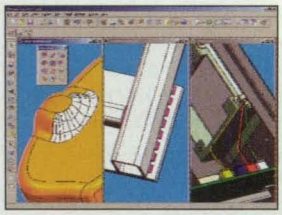
CAD2PDF™ server-based software from Layton Graphics, Marietta, GA, converts native AutoCAD and MicroStation files to fully functional PDF files that can be viewed with Adobe® Acrobat® Reader or reviewed, redlined, annotated, marked up, digitally signed, and secured with Adobe Acrobat 5.0. The PDFs retain vector resolution and convert text in the CAD files to text-searchable PDFs. CAD2PDF sits on the customer network and manages file conversion and updating of searchable indexes. **For Free Info Visit www.nasatech.com/layton**



Mechanical CAD Software

EDS, Plano, TX, has released Solid Edge® version 12 CAD software featuring Insight.NET Web services that use Microsoft's .NET technology for collaboration and communication, and a Stream/XP user interface. Other new features include wiring harness and surfacing design for applications in sheet metal and tubing, 2D to 3D data migration capabilities, and interoperability with other EDS products such as I-deas, Unigraphics, and FEMAP. **For Free Info Visit www.nasatech.com/solidedge**

Large-Display Meters

The BIG Display has been added to the iSeries meters and controllers from OMEGA Engineering, Stamford, CT. The display can be programmed to change colors among red, amber, and green at any set point or alarm point. The changes in color can be seen from a distance and equipment operators can intuitively react to changing conditions. The display can be mounted flush in a panel or surface-mounted with the included brackets. **For Free Info Visit www.nasatech.com/omegasep**

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S ❑ Computers
X ❑ Communications
O ❑ Automotive
T ❑ Transportation
M ❑ Materials/Chemicals
P ❑ Power/Energy
B ❑ Bio/Medical
J ❑ Consumer Product Manufacturing
Q ❑ Industrial Machinery & Equip.
A ❑ Aerospace
G ❑ Government
D ❑ Defense
R ❑ Research Lab
U ❑ University
Z ❑ Other *(specify)*: _____

3 **Your engineering responsibility is:** *(check one)*

A ❑ Manage Engineering Department
B ❑ Manage a Project Team
C ❑ Manage a Project
D ❑ Member of a Project Team
E ❑ Other *(specify)* _____

4 **Your job functions are:** *(please check all that apply)*

10 ❑ Design & Development Engineering (Inc. applied R&D)
12 ❑ Testing & Quality Control
13 ❑ Manufacturing & Production
14 ❑ Engineering Management
16 ❑ General & Corporate Management
17 ❑ Basic R&D
15 ❑ Other (specify)

Write in the number of your principal job function _____

5 **a. In which of the following categories do you recommend, specify, or authorize the purchase of products?** *(check all that apply)*

01 ❑ Electronics
02 ❑ Photonics
03 ❑ Computers/Peripherals
04 ❑ Software
05 ❑ Mechanical Components
06 ❑ Materials
07 ❑ None of the above

5 **b. Products you recommend, specify, or authorize for purchase:** *(check all that apply)*

32 ❑ ICs & semiconductors
33 ❑ Connectors/interconnections/ packaging/ enclosures
02 ❑ Board-level products
18 ❑ Sensors/transducers/detectors
16 ❑ Data acquisition
19 ❑ Test & measurement instruments
34 ❑ Power supplies & batteries
35 ❑ PCs & laptops
06 ❑ Workstations
36 ❑ EDA/CAE software
37 ❑ CAD/CAM software
17 ❑ Imaging/video/cameras
38 ❑ Lasers & laser systems
39 ❑ Optics/optical components
40 ❑ Fiber optics
41 ❑ Optical design software
20 ❑ Motion control/positioning equipment
30 ❑ Fluid power and fluid handling devices
31 ❑ Power transmission/motors & drives
42 ❑ Rapid prototyping and tooling
13 ❑ Metals
28 ❑ Plastics & ceramics
27 ❑ Composites
43 ❑ Coatings
80 ❑ None of the above

6 **How many engineers and scientists work at this address?** *(check one)*

A ❑ 1
B ❑ 2-5
C ❑ 6-19
D ❑ 20-49
E ❑ 50-99
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J ❑ over 1000

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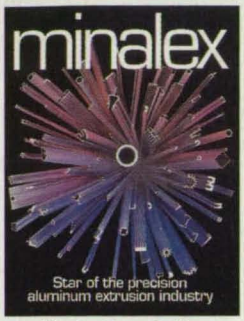

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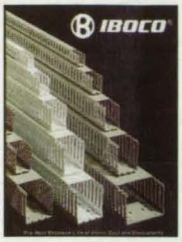

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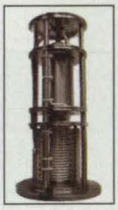

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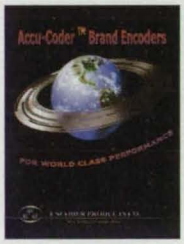

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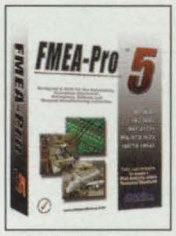

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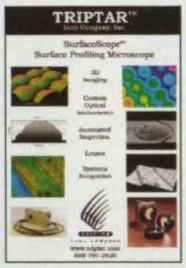

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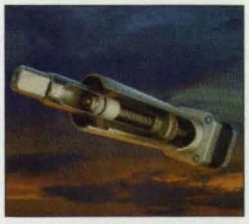

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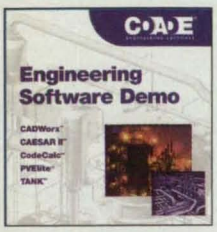

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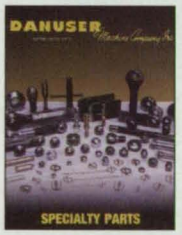

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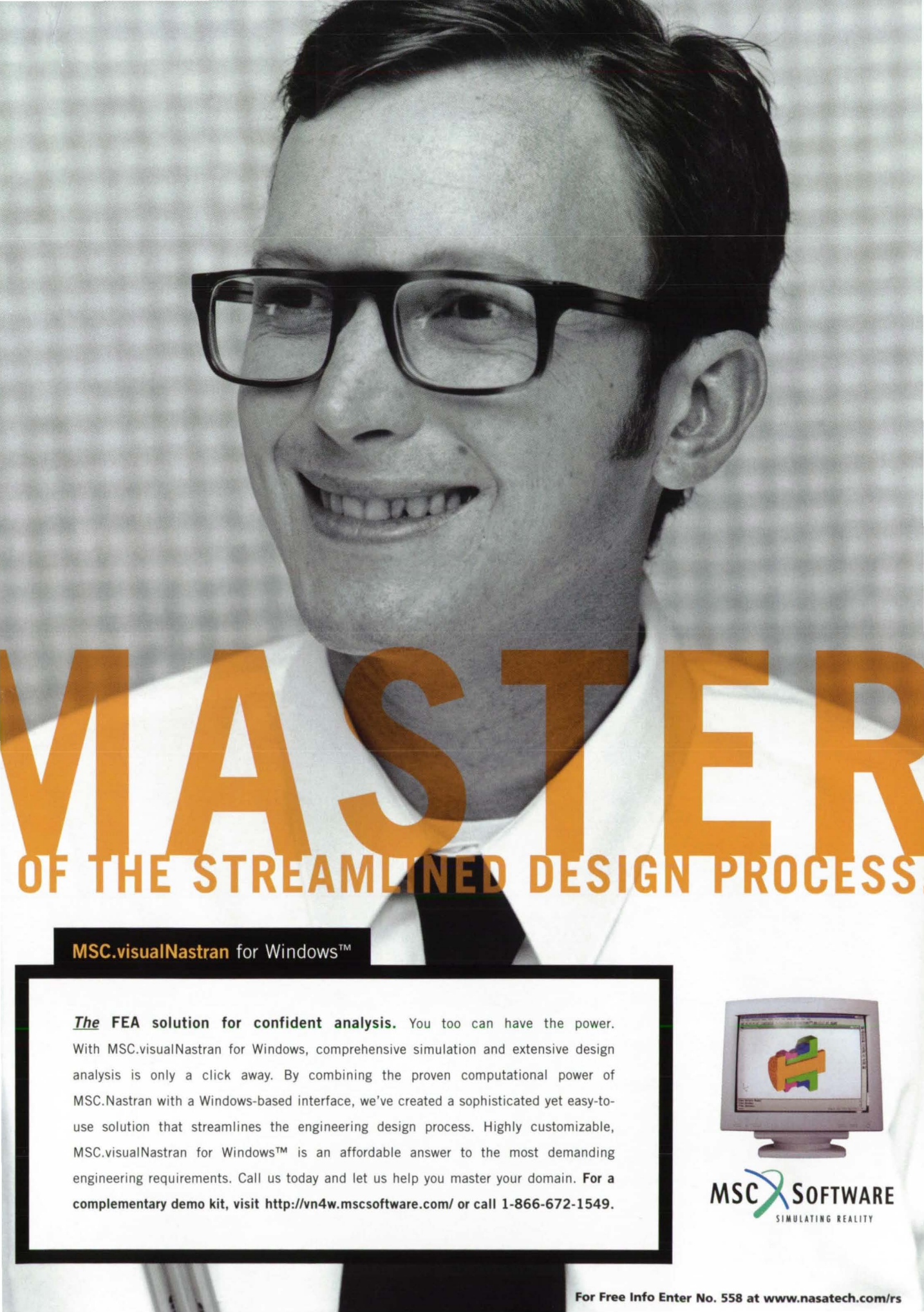

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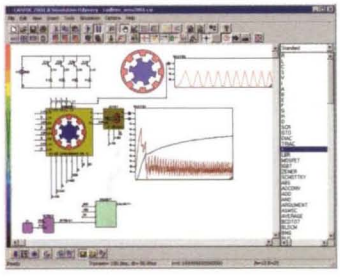

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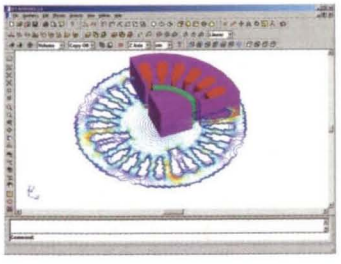

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